43D CONGRESS, 1st Session. HOUSE OF REPRESENTATIVES. Ex. Doc. No. 113.

CANAL CONNECTING THE MISSISSIPPI RIVER WITH THE GULF OF MEXICO.

LETTER

FROM

THE SECRETARY OF WAR,

IN ANSWER TO

A resolution of the House of March 14, 1871, *in relation to a ship-canal to connect the Mississippi River with the Gulf of Mexico.*

FEBRUARY 5, 1874.—Referred to the Committee on Railways and Canals and ordered to be printed.

WAR DEPARTMENT, *February* 4, 1874.

The Secretary of War has the honor to transmit to the House of Representatives, in compliance with resolution of March 14, 1871, a letter of the Chief of Engineers of the 4th instant, submitting reports of the board of engineers and of Capt. C. W. Howell relative to a ship-canal to connect the Mississippi River with the Gulf of Mexico.

WM. W. BELKNAP,
Secretary of War.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 4, 1874.

SIR: In compliance with the following resolution of the House of Representatives, dated March 14, 1871, "That the Secretary of War be, and he is hereby, requested to cause an examination and survey, with plans and estimates of cost, to be made by an officer of engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, or the navigable waters thereof, of suitable location and dimensions for military, naval, and commercial purposes, and that he report upon the feasibility of the same to the House of Representatives," Capt. C. W. Howell, Corps of Engineers, was, with your sanction, assigned to the duty of making the survey referred to. Having completed this duty and submitted his report, it was deemed advisable to obtain the judgment of a board of engineers upon the project proposed by him, and

accordingly a board was constituted for the purpose of considering it in connection with other methods for the improvement of the navigable outlet of the Mississippi River.

The reports of the board of engineers and the report of Captain Howell are submitted, as follows:

1. Report of Captain Howell, transmitting a project for a canal to connect the Mississippi River below Fort Saint Philip with the Gulf of Mexico through Isle au Breton Pass; with appendixes marked A, B, C, and map marked D.
2. Report of board of engineers upon Captain Howell's project.
3. Minority report of Colonel Barnard.
4. Report of the board of engineers on the subject of the improvement of the passes of the Mississippi, as an alternative to or in connection with the canal.
5. Minority report of Colonel Barnard.
6. Minority report of Major Warren.

By the method now in use for deepening the channel at the mouth of the Mississippi River, a depth of from 18 to 20 feet at low tide can be maintained, which will admit vessels of 19 to 20 feet draught.

The annual expenditure for securing and maintaining this depth with a width of 250 feet is $150,000, and taking into account the sum necessary to supply a new steamer every four years to replace the worn-out one of the two in use, the annual expenditure becomes $200,000.

By doubling the annual expenditure after procuring two more steamers, (at a cost of $400,000,) probably a channel 400 feet wide with a depth between 18 and 20 feet could be maintained.

This appears to be the maximum effect which may be looked for from the system of dredging.

But from the experience gained in the work the officer in charge is of opinion that the width which can be maintained with the present means will be sufficient, provided the War Department can control absolutely the use of the improved channel, a condition essential to the maintenance of the improved channel, whether it be by a canal, by jettees, or by dredging.

Respecting the practicability of constructing a ship-canal from the river near Fort Saint Philip to the deep water of Isle au Breton Pass, all the members of the board agree that there is no doubt as to its entire practicability.

To determine, however, the best line for the location of the canal across the peninsula, and the best point for its entering the river, and also the position and manner of its entering Isle au Breton Pass, requires further survey, borings, and other examinations and measurements, and the preparation of plans based upon their results.

The board, excepting Colonel Barnard, submits an estimate of the cost of constructing a canal of the dimensions stated within the limits designated, which it believes to be ample.

From this opinion Colonel Barnard dissents.

Respecting the application of the jettee system to the improvement of the channel at the mouth of the river, the board, Colonel Barnard dissenting, reports adversely both as to the difficulties attending the constructions and the cost of the system.

After a careful investigation of the question of applying this method of improvement to the mouth of the Mississippi River, I am of opinion that it does not present, either in its constructions or cost, superior advantages to the canal plan. One of the chief objections to the jettee

system is the unavoidable necessity of constantly extending the piers in the open sea, exposed to the full force of storms.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

FORT SAINT PHILIP SHIP-CANAL TO CONNECT THE MISSISSIPPI RIVER WITH THE GULF OF MEXICO.

From the general appropriation for surveys approved March 3, 1871, there was allotted the sum of $10,000 for a survey of a proposed route for a ship-canal to connect the Mississippi River at a point near and below Fort Saint Philip, Louisiana, with the Gulf of Mexico, through Isle au Breton Pass.*

Under orders from the Chief of Engineers United States Army, dated Washington, D. C., April 18, 1871, the conduct of the survey devolved on the undersigned.

The survey was completed several months ago, but report has been unavoidably delayed until this time.

Report is required on the following points:

1st. On the commercial and national importance of the projected canal.

2d. On the feasibility of the project.

3d. On the probable cost of construction.

These are to be considered in the order named; the data for consideration being obtained from the recent survey, and from other sources available, which are named in the list of authorities appended.

IMPORTANCE.

The importance of securing an adequate outlet for the commerce of the Mississippi Valley is too thoroughly appreciated by the representative men of the valley to require in this report more than a general statement.

The valley principally depends for its development on the products of its agricultural population—on its grains, cotton, sugar, and its beef and hog products. For these there is a large European demand, the supply of which adds materially to the wealth and growth of the country.

Active competition from other sources of supply, favored with cheaper labor and transportation, keeps down the market abroad, so that with our present means for transportation from the far interior to the seaboard the value of the product in the home market is kept at a figure which does not always fairly remunerate the producer for his labor, or offer a stimulus to increased production.

The advantages to be derived from works of internal improvement best calculated to insure the producer a better return for his labor are obvious.

Railroad transportation for cheap and bulky freight over long distances is necessarily, and has been found by experience, too expensive to offer the

*This survey was directed by a resolution of the House of Representatives dated March 14, 1871.

producer hope for advantage to be gained from increase in number of lines and amount of rolling-stock. He has, therefore, recently turned attention to those known and cheaper routes overlooked during the prevalence of the mania for railroad extension. Of these, the routes via the lakes, the Saint Lawrence River and Erie Canal, by the patronage bestowed on them when not ice-bound, attest the importance of similar routes projected. The popular feeling in favor of water-routes from the interior to the seaboard is further shown by the interest manifested in urging the extention of the James River and Kanawha Canal, the project for a canal to connect the Tennessee River with the harbor of Savannah, the yearly demand for continued improvement of western rivers and of the bars at the mouth of the Mississipi River, and finally in this project for the Saint Philip Ship-Canal.

The means for securing cheap transportation via the Mississippi River and its tributaries to the excellent harbor of New Orleans are promised by the substitution of lines of model barges, carrying large freights on a light draught of water, and towed by comparatively inexpensive steam tow-boats, for the expensive, short-lived steamboats heretofore engaged in traffic on those waters. The improvement of western rivers is yearly diminishing the risks attending their navigation. The advantages offered for transportation from the West to the sea, via this route, have attracted attention, and increasing capital from at home and abroad, and there is now every reason to expect that these great natural highways will become, as they ought to, the commercial routes connecting the Mississippi Valley with the eastern seaboard and with foreign countries.

That this desirable end may be attained it is first necessary to assure, beyond matter of doubt, adequate entrance to the Mississippi, at all seasons of the year, for sea-going vessels of the largest freighting capacity requisite to afford the cheapest freights.

Congress has heretofore, with yearly increasing appreciation of this necesssity, and recently with increased liberality, fostered the various plans presented for giving such entrance. The results have been such as to warrant yet more liberal action.

With the success attending the work of dredging the bar at Southwest Pass during the past two years, the commerce seeking the port of New Orleans has grown rapidly.

Lines of steamships before in the trade have built new vessels for it; other old lines have been attracted to it; new lines have their vessels in course of construction; and sailing-vessels, in greater number than before, have engaged in it, all taking fuller cargoes, making quicker trips, with greater profit to owners and reduced expense to shippers. The cotton-trade of the upper cotton region, for a time partially diverted from this route, is returning, and a grain-trade has been inaugurated, which promises to attain large proportions.

While the great benefit already derived from dredging is acknowledged, there remains, in the minds of commercial men, doubt as to its continuance to meet the growing demand for deeper-draught vessels.

There is yet more serious doubt regarding the continuance of suitable action on the part of Congress in making appropriations seasonably and in amount to prevent interruption of the work.

Distrust in the continued effectiveness of dredging can only be overcome by long-continued success, and simply retards commercial progress. Distrust in the continued good will of Congress is of more serious import.

The work in progress is dependent for its continuance on an annual

appropriation; it is of a character requiring continued work; suspension for a few weeks or months will permit the natural agencies always at work to obliterate all evidences of previous improvement and return the channel across the bars at the river outlets to their normal and obstructed condition. Such occurrence would be disastrous in the extreme. It would ruin the commerce now promising such good results, ruin the merchants engaged in it, and destroy confidence in plans for its revival at any future time. Yet such occurrence is not improbable, as evidenced by the past record of the work.

Legislative economy enters too largely into the spirit of American politics to permit of men engaged in legitimate business staking their wealth where it will depend on the turn legislation may take.

What is *required* to inspire confidence in the future of the commerce of the Mississippi River is a *permanent outlet, not one of uncertain tenure.*

Dredging, from its dependence on legislative *action*, does not offer such, *nor do I believe it* capable of offering more than a depth of 20 feet the year round, a depth not considered *adequate*. It is conceived that *this canal project* does. The magnitude of the interests involved appears to warrant a trial of the project.

THE PROJECT.

The project for this canal has been agitated for the past forty years. It has had its advocates, principally among local engineers and merchants, but has been recommended by higher authorities as a final resort should dredging fail or ultimately prove inadequate to fully meet the growing wants of commerce. Its feasibility has never been made the main subject of discussion or objection, but it has always been discarded on the ground of its supposed cost, estimated greater than the amount of commerce it was designed to aid was presumed to warrant. This objection has now lost the force it once had, and, if at all considered, can have no special weight in deciding for or against the construction of the canal.

The question of feasibility is the only one requiring consideration. To settle this, and at the same time gain the information required for making plans and estimates for the canal, has been the object of the recent survey.

PREVIOUS SURVEYS.

A reconnaissance of Breton Island Pass made by British naval officers about 1775, the results of which were made public, (*in chart submitted,) though made for other purposes, affords the earliest known data bearing on the project.

An examination is reported to have been made by Maj. Benj. Buisson, State engineer of the State of Louisiana, about 1832, on the results of which Major Buisson appears to have originated and recommended this project by his reports, giving to it, at that time, considerable prominence. Outside of bare mention in reports and correspondence of later date, I have found nothing to show that Major Buisson made more than a simple examination on which to base his project.

The representations of Major Buisson, supported by the action of the

* Not published until 1823. Enlarged copy of chart submitted, marked D.

legislature of Louisiana and of the Chamber of Commerce of New Orleans, induced Congress to authorize an investigation of the project. This was made early in 1837 by Capt. Wm. H. Chase, Corps of Engineers, U. S. A., who reported favorably.* This report was based on a hurried reconnaissance, and was not considered satisfactory. In consequence, a survey was ordered in 1838, and made under the direction of Capt. Andrew Talcott, Corps of Engineers, U. S. A., the plot of which is submitted. (Chart C.)

The report of Col. J. J. Abert, chief topographical engineer,† based on the results of this survey, caused the abandonment of the project by Congress.

In 1858 Mr. R. Montaigu, civil engineer, revived the project, made an examination, (the character of which I have not been able to ascertain,) and published a voluminous pamphlet (copy submitted, marked H) in support of his views. The death of Montaigu and the outbreak of the rebellion suspended consideration of the project.

In 1869, the Coast Survey extended its work to cover Isle au Breton Pass, (chart submitted, marked C,) the results of which agree with those obtained by our survey. The project was finally brought to the attention of Congress during the winter of 1869–'70, by prominent merchants of New Orleans, and the undersigned directed the report on its feasibility. Such report was rendered, based on the results of a personal reconnaissance, and represented the necessity for making a more thorough survey than had yet been made. Such survey was directed, completed, and its plot is submitted, (marked A.)

THE SURVEY.

The field-work was commenced November 8, 1871, and concluded March 13, 1872. The instruments used were of Windeman's and Gurley's best make. The assistants employed were skilled in the duties assigned them.

Lieut. H. M. Adams, Corps of Engineers United States Army, was placed in charge of operations in the field, and has made many of the computations for dimensions and cost of construction.

After measurement of a base and completion of the primary triangulation, the party was divided into three.

Assistant F. M. Eppley was put in charge of all hydrographic work, Assistant Thomas Larkin in charge of topography and leveling, Assistant W. Lannegan in charge of boring party.

The results of the survey are displayed on chart A, as given in the following statement:

Breton Island Pass.—This is the western of the two passes connecting the large body of water known as Breton Island Sound with the Gulf of Mexico. Its minimum width is about 33,000 feet; minimum area of cross-section about 536,000 square feet; maximum depth in throat of pass, 36 feet at mean low tide; and depth over the bar at the mouth of the pass, 28 feet. The axis of the pass lies nearly southeast and northwest. The gulf approach is from the southeast, and is flanked on the one side by the Chandeleur Islands, Errol Islands, and Isle au Breton; on the other by the land forming the east bank of the Mississippi River, the two flanks forming with each other nearly a right angle, having the pass at the vertex.

* See Ex. Doc. No. 173, House Reps., 24th Cong., 2d session.
† See Ex. Doc. No. 2, page 684, vol. 1, 26th Cong., 1st sess.

The approach is well covered except from the southeastward, and offers abundant room and good holding ground for the anchorage of a large fleet. The bottom is soft and sticky in the deeper portions of the pass and approach, and hardens from the 20-foot curve toward the shore lines. The islands are of sand, and the Mississippi shore line an alluvial, marshy formation, fringed with sand-reefs. At its head the pass expands abruptly into Breton Island Sound, and shoals rapidly.

The great depth of the pass is due to the tidal currents through it. Observations were made to determine the velocities of these currents, floats being used for the purpose, but with such unsatisfactory results as to make them valueless.

A computation has been substituted, based on the record of tide-gauge, kept at Sable Point, (diagram submitted, marked F,) the *minimum area* of cross-section of pass, (section submitted, marked F F,) and the superficial area of that portion of Breton Island Sound affected by the tides through the pass, (see appendix marked G.) "It is best to use such calculations only for the purpose of computing the probable effect of alterations." (Rankine.) It is for this purpose alone the information is required.

By these computations, for the time covered by the gauge-record, the velocity of the inward or flood-tide current was found to range from zero to 1.06 feet per second; that of the outward or ebb-tide current from zero to 1.75 feet per second. Higher tides than those observed have been known to occur, but they were of longer continuance than any shown on diagram, and it is possible caused no stronger flood-current than is shown, but a stronger ebb-current. No reliable information could be obtained regarding these extraordinary tides, from which to determine the rise and fall that would have been indicated by the Sable Island gauge. It is only known that they seldom occur, are caused by southeast hurricanes, which continue for two or three days, and that, during their continuance, water from the Gulf has been known to flow into the river, over the lower portions* of the river bank, below Fort Saint Philip.

The portion of Breton Island Sound daily filled and discharged through Breton Island Pass has a superficial area of water-surface of about three hundred and five square miles. Its northern and western shore line is covered by numerous small islands and oyster-reefs, and indented with bays and bayous connecting with lakes in the Lake Borgne Peninsula. The depth of water in the sound ranges from 15 feet at the head of the pass to a few inches at the shore line. The bayous connecting the lakes with the sound have a depth of from 20 to 30 feet. The lakes are shallow. The shores and bottom are of alluvial formation; the islets generally of sand. There are no streams entering into the sound, and no connection with the Mississippi River, even during the season of high water in the latter, the levees, which extend to Fort St. Philip, effectually cutting off such communication above the head of Breton Island Pass.

Outside of the pass, and at the foot of the Fort Saint Philip Peninsula, there is a break in the river-bank known as Cubit's Gap, through which the Mississippi River makes its first discharge to the eastward. This

* The difference between lowest and highest tides observed by this survey was 3.70 feet. (See Fort Point gauge, Diagram F.) The greatest difference observed in 1851 and January, 1852, in Bayou Saint Philip was 4.92 feet. (See Humphreys & Abbott's Physics and Hydraulics of Mississippi.) The first-named gauge was the entrance to the bayou, the second at the head. The modifying action of the bayou could not be ascertained, the old bench-mark at Fort Saint Philip having been lost.

discharge is only during the flood stage of the river, and during this stage much material in suspension is carried through the gap from the river to be deposited in Bird Island Sound, some of which may find its way into Breton Island Sound, as is hereafter explained.

The next eastward outlet of the river is through the à Loutre Passes, and the numerous small bayous branching from them. These outlets are so situated in relation to Breton Island Pass, as will be seen by reference to a map of the Mississippi Delta, that during the prevalence of southerly winds some of the muddy water discharged through them must be carried by the littoral current, induced by such winds, in the direction of the pass, and not only cause deposit in the bayous of the Saint Philip Peninsula, but on rare occasions, by extending into Breton Island Sound, cause slight deposits there, tending, at some time in the very remote future, to materially lessen the capacity of the sound as a tidal reservoir.

The Saint Philip peninsula, through which it is proposed to carry the trunk of the canal, is entirely (with the exception of the Sand Islands skirting its eastern border) of alluvial formation, the character of which is shown by the borings, sections of which are shown on chart A.

The greater part of the peninsula is covered by shallow bays and lagoons, the only firm land being a narrow strip along the river-bank, and that afforded by the Sand Islands. The formation is entirely similar to that on which the city of New Orleans and the heavy structures of Forts Jackson and Saint Philip are built.

The river for several miles of its length along the reach available for the river end of the canal is nearly straight, and the water deepens rapidly from the shore-line. The banks are stable because through this reach the river-current is parallel to them, and has not sufficient velocity to further abrade them, as it does in the bends above.

The range of the river between extreme low and extreme high water was found to be about 6 feet by reference to gauge-record kept at Fort Jackson during the past year. This has been adopted as the extreme lift of the river-lock for the canal, the least being zero.

The facts above stated, together with those referred to as displayed on charts and in appendixes submitted, are all that are required for the discussion of the feasibility of the project for this canal.

DISCUSSION OF FEASIBILITY.

The feasibility of the project depends, first, on finding Breton Island Pass, in its present condition, not subject to material deterioration as regards depth and other dimensions, within such reasonable period of time as may be assumed sufficient to repay, in the benefit commerce may derive from the canal, the cost of its construction. Of this we are to judge, first, from the charts of past surveys, the earliest of which, fortunately, dates back quite one hundred years. Four of the charts are presented, reduced to the same scale for ease of comparison, and will be found marked A, B, C, and D. Though the soundings on these are not referred to the same plane, (being referred to mean low tide as determined by observation made during the continuance of the surveys which they separately represent,) from the manner in which the plane of reference was obtained in each case, there can be but such slight difference that we may ignore it and compare the soundings as if referred to the same plane.

Making the comparison, we find there has been, within the past one hundred years, no noticeable change in the depth of water over the bar

at the entrance to the pass, and that the entrance has, if anything, improved by widening. We find the depth in the throat of the pass maintained, and but unimportant changes in the contour of the head of the pass, where it spreads out into Breton Island Sound. From inspection of the charts, the conclusion must be such as to warrant belief that no greater changes will be observed during the next one hundred years, unless new causes for change are introduced.

Let us consider the possibility from new causes.

The dimensions of the pass are determined by the volume and velocity of the tidal currents through it. These are dependent chiefly on the area of the reservoir to be daily supplied and depleted through the pass.

So long as this reservoir (the west end of Breton Island Sound, and the bays, bayous and lakes connecting with it) retains its present area, there can be no change resulting from natural causes alone in the dimensions of the pass. That this area cannot be materially diminished by silting is evident from the following:

The ebb-current through the pass being always stronger than the flood-current, is able to return to the Gulf the greater part of what silt may be brought by the flood-current from the eastern outlets of the Mississippi River. These outlets are at a considerable distance from the pass. The present indications are that the nearest is filling, and we know that the others are pushing out farther into the Gulf, increasing their distances from Breton Island Pass. There is no reason to apprehend the formation of new outlets above the present ones. Should there be, at any future time, cause for apprehending breaks in the river-bank that might result in injury to the pass, comparatively inexpensive levees can be built to effectually guard against them.

As before stated, there are no streams emptying into the sound, and the Mississippi River is securely leveed. There can be no silt brought in from that direction, except through a possible crevasse. There can be no silt brought in from the northeastward through Chandeleur Sound, since the tides through Grand Gosier Pass effectually cut it off. Filling of the sound by the gradual growth of oyster-beds and reefs is barely considerable.

Since existing sources of silt are being blocked up or further removed, and since possible new sources can be easily guarded against, I conclude that the area of Breton Island Sound will remain as now for an indefinite time, and the dimensions of Breton Island Pass remain unchanged from natural causes.

The constructions (the jettees) required to carry the debouche of the canal to the deep water of the pass will cause changes, the general character of which may be predicted.

The area of cross-section of the pass will be diminished by the construction of the jettees proposed by 70,000 square feet.

The area of Breton Island Sound remaining unchanged, the volume of water going through the pass to fill or deplete the sound daily will be, after the jettees are built, the same as if they were not constructed. This will cause increased velocities of the tidal currents and increased scour of the bottom, and of the Breton Island side of the pass, until such time as the present area of cross-section is restored.

The axis of the pass will be shifted to the eastward and its direction slightly changed. The contour of the head of the pass will be considerably changed, and the west end of Breton Island will probably, considering the character of its formation, be abraded unless protected by works of art.

From the character of the bottom in the deeper portions of the pass, it is probable the pass will regain its normal dimensions entirely at the expense of the Breton Island side. Unless the end of the island is protected with such protection as may be necessary, the pass will deepen.

The extent of the changes which the jettees will effect can only be definitely ascertained after construction of the latter. Injurious changes may be prevented by the protection of the west end of Breton Island, as may be found necessary in the course of construction.

While the effect of the proposed jettees on the east side of the pass cannot be accurately predicted, their effect on the west side, on Sable Island, may be predicted with certainty. The angles between the shore-line and the jettees will partially fill with sand and other deposits. This has been the experience of engineers with all jettee constructions on our northern lakes, on our Atlantic sea-board, and in Europe; at the mouths of the Oder, the Vistula, and the Danube, and, recently, at the *debouché* of the North Sea Canal and of the Suez Canal. In all these cases this filling is considered objectionable, inasmuch as the tidal currents, (shore currents,) perpendicular to the jettees, are not strong enough to prevent the ultimate growth of the shore-line incident to this filling from extending around the jettee head and obliging an extension of the jettees themselves. In the case under consideration, it is possible to secure a very strong current passing the jettee-heads, sufficient to insure us against apprehension of being called upon at any time to extend our constructions.

As there will be no current through the canal, we must expect silting immediately between the heads of the jettees, due to eddies from the currents through the pass. It is apprehended that shoaling of the entrance to the canal from this cause will not be rapid, but that there will be required to free the entrance from such deposit as may be made, each year, the services of an ordinary dredge-boat for several days, or perhaps weeks.

In the trunk of the canal there will be no silt admitted, the proposed arrangement of sluices for the lift-lock being such as to keep all river water required for the lift from passing into the canal below the lock.

Slight deposit is anticipated within the lock, the removal of which, quarterly or semi-annually, will be a very simple operation.

There will be deposit of river silt in the fore-bay of the lock, due to an eddy from the river current. The amount of this deposit cannot be calculated, and it will require occasional dredging to maintain the depth of this entrance to the canal.

The river bank at the point selected for the head of the canal, as before stated, is not subject to change, and the depth of the river bed may be expected to very gradually increase with the advance of the mouth of the river gulfward.

In conclusion, I can see no reason from the above to question the feasibility of the project, as it has heretofore been questioned, on the assumption of engineers, that Breton Island Pass will deteriorate and the canal itself fill with silt to such an extent as to require continued extensive dredging to keep it open.

In regard to the foundations for locks, reference is made to the sections of borings (Chart A) and to the specimens sent herewith.

Borings numbered 1, 2, and 3 show, at a suitable depth for the foundation of a sift-lock, a stratum of mud-lump clay, having an indicated thickness of over 20 feet, and its further thickness not ascertained. This I consider well calculated to sustain the lock shown by drawings submitted, if a solid timber platform, here recommended, is employed, or even if a pile and grillage foundation should be adopted.

As no plan of founding will be adopted, even should the construction of the canal be decided upon, except under the advisement of a board of engineers, it is not essential that I should here give reasons for favoring the platform.

Boring No. 6, in my opinion, shows that a good foundation may be had for the guard lock on Sable Island.

Excavation for trunk of canal.—This will be the least difficult part of the work to execute. It will be entirely through an alluvial formation, free, so far as has been ascertained, from rocks, stumps, and buried timber. It can all be done by dredge-boats provided with suitable carriers to transfer the spoil to the banks.

* Canals have been successfully carried through a similar formation by allowing the excavation of a large cross-section with easy slopes, and by giving the embankments a wide base as compared to their heights. The cross-section of this canal and embankments must be determined while excavation is in progress, and be varied to suit the peculiarities of the formation found in the several sections of the work.

For purpose of estimate, a uniform cross-section† has been assumed with sides given, the slope found in the river at the head of the canal. The embankments of the canal at some points may require protection of their outer slopes by facines or wicker-work, or by a growth of willows. Throughout their greater part, sodding with Bermuda grass will be sufficient to prevent washing of the slopes. Washing of the sides of the excavation may be avoided by introducing the towage system of navigation now in use on the River Seine, in France, and Elbe, in Germany, which, I think, will be better and more economical than a railroad and towing-locomotives on the embankment.

The jettees.—The location of these is shown on Chart A. The foundation available is shown to be a good one. Similarly-constructed jettees have been employed at the Salina, mouth of the Danube, proving efficient, substantial, and economical.

There can be no doubt of the ability of even an engineer of ordinary capacity toconstruct these jettees, in the manner indicated by the drawings, so as to withstand the strongest seas to which they may be exposed. The dimensions adopted for purpose of estimate may require modification in the course of construction, as they are based on calculations having factors the value of which could not be accurately determined.

PLANS FOR CONSTRUCTION.

The general and detailed plans for the various constructions pertaining to the canal, and herewith submitted, were drawn up more for the purpose of estimate than with a view to their ultimate adoption without modification. They have been as carefully considered as the time at my command for such purposes would permit.

While some points of the plan are original, the greater number, it will be observed, have been adopted from existing works; for example, the general plan and details for gates, &c. (Due acknowledgment will be found on the drawings.) In all such cases dimensions have been changed to suit the new conditions imposed.

The drawings are intended to be so complete as to render a detailed description unnecessary.

*North Sea Canal of Holland.

† Width at bottom, 200 feet; depth, 27 feet; slope, 1 on 2.

GENERAL DESCRIPTION.

The lift-lock is 400 feet in length between gates, 80 feet wide at top, and has a depth of 27 feet over the sill at mean low tide in the Gulf. The side walls and bottom are of beton, the walls faced with granite. These are founded on a solid timber platform, 6 feet in thickness, extending the whole length and breadth of the lock, composed of layers of 12 inch by 12 inch squared timber alternately crossed at right angles and bolted together in the manner adopted for the caissons for piers of the East River suspension bridge, the whole forming a rigid beam calculated to uphold without deflection the weight of the superstructure. This foundation rests upon a stratum of mud-lump clay known to be at least 20 feet in thickness. Seepage is cut off by rows of close piling extended from the lock 60 feet into the bank. The platform is surrounded by a double row of close piling, the heads of the piles being strongly strapped to the platform.

The gates are of iron, circular in plan, and of the kind known as floating gates. Their floatation is calculated, without ballast, for a draught of 28½ feet, and for greater depths water-ballast will be introduced or discharged, as may be made necessary by the fluctuations of the tides. The miter-sills are wrought-iron trusses. The opening and closing of the gates will be effected by chains and hand winches.

The sluices for filling and emptying the lock are large cast-iron pipes, laid in the side walls just below the level of extreme low water in the river. Water is received from the fore-bay to fill the lock, distributed by branch-pipes the whole length of the lock-chamber, then sluiced out through the same pipes into open ditches on either side of the canal. By this method the purest water obtainable from the river is sluiced in on the cushion of salt water already in the lock, and its specific gravity being less than that of the latter, it remains long enough on top to be, with the greater portion of its impurities, sluiced outside of the canal.

The sluice-gates are arranged with hydraulic lift, and are lowered by their own weight.

The lock is located 400 feet from the river bank. The approach to it is between two timber wharves, which, besides forming the sides of the entrance, are extended on either side several hundred feet along the river bank, for the convenience of vessels waiting to pass the lock or awaiting towage to New Orleans. The lower approach is similarly arranged.

All the piles used in this and in other structures are to be corbelized by the Seeley process.

The guard-lock is entirely similar in design and construction to one end of the lift-lock. It is intended to close the canal on occasions of extraordinary storms, which raise the water in the Gulf higher than that in the river.

The details adopted for the jettees are well enough shown by the drawings.

The construction is one of a substantial, though temporary, character, and must ultimately be superseded by one of béton, based on the foundation this one will afford.*

ESTIMATES.

The estimates presented have been based on the cost of material and

* The reason for adoption of this character of structure is, that it will be economical and can be constructed sooner than permanent jettees.

labor for small works undertaken in the neighborhood of the proposed canal.

The magnitude of this work will apparently justify belief that material may be obtained at less cost than that estimated. It is also evident that the material used for coffer-work may be taken up and used in other parts of the work.

These considerations induce me to leave out of my estimate amounts required for engineering, superintendence, and contingencies.

With this explanation the following estimates are submitted:

Estimate.

For excavation of trunk of canal and sea entrance	$3,966,673 50
For construction of lift-lock	750,900 00
For construction of coffer for same	250,938 82
For construction of jettees	1,949,497 70
For construction of guard-lock	226,885 80
For construction of coffer-work for same	118,068 28
For construction of wharf and excavation at river entrance	107,839 48

SUMMARY.

1. Excavation of trunk	3,966 673 50
2. Construction of lift-lock	750,900 00
3. Construction of coffer for same	250,938 82
4. Construction of jettees	1,949,497 70
5. Construction of guard-lock	226,885 80
6. Construction of coffer for same	118,068 28
7. Construction of wharf and river entrance	107,839 48
Grand total	7,370,803 58

SUMMARY OF CONCLUSIONS.

1st. The construction of the canal is a matter of great importance.

2d. The project is feasible, and its execution presents no great difficulties to be overcome by the engineer.

3d. The total estimate of cost approximates $7,400,000, in round numbers.

TIME REQUIRED FOR COMPLETION.

If suitable appropriations are made, the work can be completed within three years of the date of its commencement.

To do this, an appropriation of $3,000,000 should be made available for the first year, $3,000,000 for the second year, and the balance for the third year.

Should completion be delayed a longer time than three years from date, a new dredge-boat will be required, at an expense of about $250,000, to continue the work of dredging at the mouth of the Mississippi River, maintaining its present effectiveness.

The cost of construction will be increased.

Respectfully submitted.

C. W. HOWELL,
Captain of Engineers, United States Army.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., February —, 1873.

LIST OF SPECIAL AUTHORITIES CONSULTED.

To ascertain importance of the project.

Statistics from the Bureau of Agriculture, made available through newspaper publications.

Commercial statistics from reports of various commercial bodies.

Report of the Chief of Engineers for 1871, pp. 632–3, &c.

Pamphlet compiled by E. Lorraine, chief engineer James River and Kanawha Canal Company, published by the company in 1869.

Reports of Chief of Engineers, United States Army, since 1867.

To ascertain feasibility.

For character of Breton Island Pass, survey of 1871–'72, Chart A, submitted; Coast Survey chart, 1869, Chart B, submitted; Talcott's survey, 1837, Chart C, submitted; reconnaisances 1775–'76, published 1823, Chart D, submitted.

For character of formation of Fort Saint Philip Peninsula and of Breton Island, charts above referred to, reports of various engineers, &c.

Sections displayed on Chart A.

Specimens* of borings in boxes herewith.

Tides through Breton Island Pass.

Observations made 1871–'72 at Sable Island. Diagram submitted, marked F.

Observations at Fort Point. Record submitted.

Observations in Bird Island Sound. Record not submitted.

Observations in Lucas Canal. Record not submitted.

Currents through Breton Island Pass:

Velocity computed, and computations submitted in appendix, marked G.

Velocity computed for increase due to construction of jettees. (See Appendix G.)

Rise and fall of the Mississippi River:

Humphreys and Abbot. Gauge record at Fort Saint Philip in 1851.

Gauge kept at Fort Jackson, 1871–'72.

Effects of severe storms; from statements of residents below Fort Saint Philip.

Effects of waves and tidal currents on jettees, &c.

Stevenson on harbors. Foundations on compressible soils.

Memoir of General Richard Delafield, United States Army, published by order of Light-House Board, December 1, 1868, and several of the authorities cited by the author.

Report of Brevet Major-General J. G. Barnard, Corps of Engineers, United States Army, on the North Sea Canal of Holland.

London engineering, 1872–'73, on same.

Personal observations and experience. Excavation through compressible soils.

Personal observations in New Orleans, at the Mexican Gulf Canal, and on the coast of Texas.

Reports regarding excavations for the North Sea Canal of Holland.

Reservation of timber. Report of T. J. Cram, Colonel of Engineers and Brevet Major-General, United States Army, published by Engineer Department, 1871.

* Specimens not forwarded. In making arrangements for packing it was found that many of the labels had fallen off and been misplaced, so that but few of the specimens could be identified with certainty.

Report made to the board of public works, Washington, D. C., 1872.

Construction of timber jettees. Professional papers royal engineers, Vol. XIII, new series, Paper V.

Report of United States engineer on improvement of lake harbors; construction in beton.

Professional paper 19, Corps of Engineers, United States Army.

Various reports on application of locks and jettees in Germany and England.

Experience at Forts Jackson and Saint Philip.

Previous reports and opinions of engineers and others in relation to the project.

Ex. Doc. No. 173, House Representatives, 24th Congress, 2d session.

Vol. VII, p. 463, Ex. Doc. 26th Cong., 1st session.

Vol. I, p. 684, Ex. Doc. 26 Cong., 1st sess.

Reports, &c., printed by Chamber of Commerce of New Orleans in 1837.

Humphreys and Abbot. Physics and Hydraulics of the Mississippi River.

Project of R. Montagu, chief engineer, 1869. Copy submitted, marked H.

Memoir of Wm. M. Burwell, esq. Copy submitted, marked I.

List of maps and charts submitted.

A. Chart of survey, 1871–'72.
B. Coast Survey chart, 1869.
C. Talcott's survey, 1837.
D. Rec. 1775, &c. Pub. 1823.
Plate I. Plan, section, and elevation of lift-lock.
Plate II. Details of lift-lock.
Plate III. Lower approach to lift-lock.
Plate IV. River approach to lift-lock.
Plate V. Details of coffer-work for lift-lock.
Plate VI. General plan of guard-lock and approaches.
Plate VII. General plan of jettees, sections of same, and details of jettee-heads.
F. Diagram of tide observations.
F F. Sections of Breton Island Pass.

APPENDIX.

A.

To compute the velocity of tidal currents through Breton Island Pass.

Given:

1. Tide-gauge record at Sable Point for December, 1871, January and February, 1872.
2. Minimum cross-section of the pass.
3. Area of portion of Breton Island Sound affected.

[Computation by First Lieutenant C. E. L. B. Davis, Corps of Engineers, United States Army.]

Notation and formula.

V = velocity of current in feet per second.
a = area of reservoir, 305 square miles.
h = rise or fall of each observed tide, in feet.
t = time between high and low water, each tide.
b = area of cross-section of pass, 536,000 square feet.
ah = quantity flowing through in time t.
$\frac{ah}{t}$ = quantity flowing through in unit of time.

$$V = \frac{\frac{ah}{t}}{b} = \frac{ah}{bt} = \frac{a}{b} \times \frac{h}{t}$$

Constant factor, $\frac{a}{3600 b} = \frac{305 \times 27878400}{3600 \times 536000}$

Day of the month.	Ebb. Value of t in hours.	Ebb. Value of h in feet.	Ebb. Velocity in feet per sec.	Flood. Value of t in hours.	Flood. Value of h in feet.	Flood. Velocity in feet per sec.
11	12.0	1.6	0.5876	12.0	1.97	0.7234
12	11.5	2.47	.9464	13.0	2.6	.8813
13	9.0	2.4	1.1751	12.0	2.9	1.0649
14	13.0	2.1	.7118	9.0	1.8	.8813
15	13.0	2.2	.7457	11.5	1.7	.6514
16	12.0	1.8	.6609	11.0	1.9	.7611
17	9.8	1.6	.7834	10.0	1.4	.6619
18	6.5	0.9	.6101	6.0	0.6	.4406
19	8.5	0.6	.3110	7.0	0.6	.3777
20	2.0	0.3	.6609			
22	10.0	1.3	.5728	12.5	1.7	.5993
23	10.0	1.6	.7051	10.0	1.2	.5288
24	10.0	1.7	.7491	11.5	1.45	.5556
25	10.0	1.75	.7712	12.0	2.8	1.0282
26	8.0	1.7	.9364	10.5	1.5	.6295
27	11.5	2.0	.7664	12.5	2.5	.8813
28	7.0	1.8	1.1331	11.5	1.5	.5747
29	10.0	1.9	.8372	10.7	1.8	.7413
30	10.0	1.7	.7491	9.0	1.5	.7344
31	9.0	1.4	.6854	11.0	1.1	.4406
Sum			15.0987			13.1573
Mean			.7549			.6925

January, 1872.

Day of the month.	Ebb. t.	Ebb. h.	Ebb. V.	Flood. t.	Flood. h.	Flood. V.
1	10.0	2.2	0.9694	9.5	1.4	0.6494
2	8.5	0.8	.4174	9.0	0.6	.2937
3	10.5	0.8	.3357	7.5	0.75	.4406
4	12.0	0.55	.2019	8.5	0.57	.2955
5	8.5	0.57	.2955	9.0	0.9	.4406
6	10.0	1.0	.4406	8.7	1.2	.6078
7	8.8	2.1	1.0515	14.5	2.33	.7081
8	9.4	2.13	.9985	12.0	2.4	.8813
9	11.3	2.6	1.0139	13.0	2.4	.8135
10	9.5	2.52	1.1689	10.5	2.42	1.0156
11	9.5	2.5	1.1596	11.5	2.4	.9196
12	9.0	2.12	1.0379	10.7	2.02	.8319
13	12.0	2.1	.7711	10.0	1.75	.7711
14	11.0	0.95	.3805	8.8	1.15	.5758
15	12.5	1.45	.5112	8.0	0.6	.3305
16	8.0	0.4	.2203	11.0	0.4	.1602
17	1.0	0.2	.8813	13.0	0.85	.2881
18	10.0	0.95	.4186	11.0	1.0	.4006
19	10.7	0.95	.3912	12.0	0.85	.3121
20	10.0	0.85	.3744	10.0	1.27	.5596
21	12.0	2.15	.7895	10.5	1.33	.3581
22	9.5	1.63	.7561	12.0	2.08	.7638
23	8.5	1.95	1.0109	13.5	2.1	.6854
24	8.2	1.64	.8813	13.0	2.24	.7593
25	8.5	1.6	.8295	14.3	2.22	.6841
26	9.0	2.22	1.0869	14.0	2.0	.6295
27	10.5	1.7	.7134	10.2	1.4	.5875
28	9.5	1.83	.8488	10.7	0.95	.3912
29	10.0	1.24	.5464	10.0	0.72	.3173
30	12.0	0.8	.2937	12.0	0.5	.1836
31	1.0	0.1	.4406	15.0	1.3	.3819
Sum			21.2338			17.2373
Mean			0.6849			0.5560

February, 1872.

Day of the month.	Ebb. t.	Ebb. .	Ebb. V.	Flood. t.	Flood. h.	Flood. V.
1	1.5	0.2	0.5875	6.5	0.4	0.2712
2	12.0	1.0	.3672	8.0	0.6	.3305
3	12.0	1.8	.6609	8.5	1.1	.5702
4	9.0	1.4	.6854	10.0	1.6	.7051
5	8.5	1.8	.9331	14.3	3.13	.9645
6	9.8	2.43	1.0926	12.9	1.9	.6490
7	9.0	1.9	.9303	13.0	2.34	.7932
8	10.0	2.54	1.1192	15.0	2.2	.6463
9	8.5	2.2	1.1415	11.0	1.5	.6009
10	11.0	1.6	.6410	14.0	1.85	.5823
11	11.0	1.55	.6209	8.5	1.25	.6480
12	8.3	1.15	.6106	15.0	0.75	.2203
13	12.0	0.55	.2019	2.0	0.2	.4406
14	4.5	0.5	.4896	23.0	0.6	.1149
15	6.0	0.8	.5875	9.0	1.0	.4896
16	10.5	0.8	.3357	9.0	0.9	.4406
17	8.5	1.2	.6221	10.5	1.7	.7134
18	11.7	1.5	.5649	7.0	1.6	1.0072
19	16.0	1.5	.4131	9.5	1.5	.6957
20						
21				11.0	1.33	.5328
22	9.0	0.83	.4064	8.3	1.0	.5309
23	9.0	1.5	.7344	13.5	1.9	.6202
24	7.0	1.4	.8813	6.5	1.0	.6779
25	10.0	0.8	.3525	6.0	0.4	.2937
26	14.0	0.6	.1888	3.5	0.4	.5036
27						
28						
29	7.0	0.7	.4406	11.0	0.95	.3805
Sum			15.6090			14.4231
Mean			0.6244			0.5547

Mean of 76 ebbs	0.6834
Mean of 76 floods	.5897
Highest velocity ebb-tide, December 13	1.1751
Highest velocity flood-tide, December 13	1.0649
Lowest velocity ebb-tide, February 26	.1888
Lowest velocity flood-tide, February 14	.1149
Mean of 76 ebbs	0.6834
Mean of highest and lowest ebbs	.6819
Mean of 76 floods	0.5897
Mean of highest and lowest floods	.5899

Approximate area of cross-section of proposed jettee, 70,000 square feet. 536,000 — 70,000 = 466,000 square feet, area of diminished cross-section.

Substituting this value the formula becomes:

$$V = \frac{305 \times 27,878,400}{466,000 \times 3,600} \times \frac{h}{t}$$

Substituting the values of h and t on the dates of highest and lowest velocities, both flood and ebb tides, we have:

Highest velocity, December 13, ebb-tide	1.1751
Same, with diminished cross-section	1.3516
Increase	.1765
Highest velocity, December 13, flood-tide	1.0646
Same, with diminished cross-section	1.2249
Increase	.1600
Lowest velocity, February 26, ebb-tide	0.1888
Same, with diminished cross-section	.2172
Increase	.0284
Lowest velocity, February 14, flood-tide	0.1149
Same, with diminished cross-section	.1322
Increase	.0173
Mean of increase—floods	0.0886
Mean of increase—ebbs	0.1024

B.

Memoir of the Delta Canal, from the Mississippi River, below Saint Philip, into the Gulf of Mexico, near Isle au Breton; compiled from the best sources, by William M. Burwell.

The immense resource of agricultural and other productions in the valley of the Mississippi, above the capacity of the Southern States to consume, has imposed upon the farmers, merchants, and statesmen of the West the indispensable need of a free outlet to all the markets of the world by way of the Mississippi.

The admitted obligation of the Federal Government to construct this outlet devolves upon it the duty of devising the plan, providing the means, and executing the work. We hold the Government to the responsibility, and are not willing to accept the substitution of any individual or corporation.

Various modes of deepening the outlet passes have been proposed and tried. Their advocates insist that the experiments have not been made under favorable circumstances, and some demand a repetition.

The leading plans proposed and subjected to more or less experiments are—

Dredging, dredging out, and carrying away the bar across the channel.

Concentration of current by wing-dams, caissons, and by closing all the passes except the channel pass.

Lighterage by pontons or camels.

Canalization across the land from deep water in the river to deep water in the Gulf.

We will, therefore, state the various attempts made to remove the bar upon each of the theories cited.

I. *By dredging.*—In 1839, Captain Talcott, under instructions of the War Department, attempted to open the Southwest Pass with the ordinary bucket-drag. No permanent improvement was effected, for during a single night of storm "twice as much mud" was driven by the Gulf waves into the pass as he had taken away. A tow-boat association, under the direction and at the expense of the Federal Government, attempted to open the same pass. They used the rake and harrow, and after working a year they opened a channel of 18 feet in depth for a distance of about 8,000 feet. This remained open a short time, and was prematurely and permanently closed by a single Gulf storm.

In the years 1868-'69-'70, the Government caused to be constructed, at a cost of $350,000, a steam-propeller dredge, with all the appliances which science could suggest or experience justify; she was commanded by competent and disinterested officers of the Federal Navy; these men performed their duty faithfully. The dredge-boat was repaired and altered without regard to expense, and the experiment of dredging has been conclusively made. It has failed to maintain, permanently, a much greater depth of water than that which nature has prescribed as the regimen depth of the bar.* Dredging has, therefore, proved a failure. To deepen the bar at the season when there is little current-deposit, is not very difficult. The whole labors of a season have been, and may be again, destroyed in a night.

II. *By concentration of current.*—The theory of Mr. Long has been stated by him to consist in concentration of current by closing all the passes except those destined for navigation. In 1836, Messrs. Craig & Righter entered into a contract with the Government to open two channels 1,000 feet by 18, in a straight line via Southwest Pass and Pass à Loutre, respectively. They built a break-water by driving strong piles faced, 4 feet apart, connected by 4-inch plank. This dike was built 3,000 feet in the Southwest Pass, and 550 feet in Pass à Loutre. As this contract was not renewed or continued, we may infer that the Government was convinced that concentrating the current of the Misssissippi, by plank walls, was not feasible. The experiment of deepening the channel by blasting with gunpowder was then tried, we believe, by the same contractors. It was for a time partially successful, but another storm proved that nature can replace mud under 20 feet of water much faster than man can move it away. The aggregate cost of these experiments has been estimated at more than two millions of dollars.

III. *Lighterage.*—The cost and difficulty of this mode of transportation has never justified its adoption.

Canalization.—No experiment beyond the surveys and estimates heretofore referred to has been made to test the success of a canal outlet. There are two projects before the public, proposing to connect the Mis-

* See report of officers in charge of the dredging, stating the injury done to their improved channel by the stormy weather, about 1st September, 1871.

sissippi with Lake Pontchartrain and Lake Borgne. The latter approaches completion, and will furnish an excellent mode of conducting the inboard and coastwise navigation along the numerous lakes and bayous with which the Gulf coast is connected. As neither of these side-cut canals can carry into the Gulf the maximum depth of water demanded by the great crops of the West, they cannot be accepted, even if successful, as a solution of the great questions of commerce involved.

Even did these canals offer an adequate outlet, they will have been constructed under corporate authority, and subject to a toll on the tonnage which may pass through them. The cities of New Orleans, Saint Louis, Cincinnati, and Louisville, all engaged in relieving the charges in river navigation, will accept nothing less than a free and adequate outlet to the ocean. They require that all obstructions from the cities of Pittsburgh and Saint Paul, respectively, to the Balize, shall be relieved by free canals constituting a part of the national highway.

HISTORY OF THE FORT OF SAINT PHILIP CANAL.

Some time previous to the year 1832, Mr. Benjamin Buisson, then the State engineer of Louisiana, suggested the idea of avoiding the bars of the Mississippi by a canal from Fort Saint Philip to a deep-water point in the Gulf, off the island of Breton. He made a reconnaissance of the intermediate ground, and based his works of construction into the Gulf upon the hydrography furnished by the best existing charts. From these he deemed the plan feasible, and so far impressed his views upon the legislature of Louisiana as to induce, in February, 1832, the adoption of the resolution which follows:

It appearing from a chart executed by Mr. B. Buisson, of the coast adjacent to and embracing the mouth of the Mississippi, that a canal six and a half miles long, commencing on the left bank of the river, a few miles below Fort Saint Philip, and entering the sea about four miles south of Le Breton Island, would afford an easy and safe access to the river to vessels drawing 20 feet; and being strongly impressed with the importance of an improvement thus brought into notice by the ability and public spirit of an individual, and believing that it would be of a great and incalculable advantage to the nation at large: It is therefore

Resolved by the senate and house of representatives of the State of Louisiana in general assembly convened, That our Senators and Representatives in Congress be requested to bring to the notice of the General Government the probable practicability of such a work, and to urge an early estimate and survey of the same by competent officers.

These resolutions were presented to Congress, accompanied by a memorial of the chamber of commerce of New Orleans, and so far met approval that a survey was ordered, which was reported from the War Department in 1837. From the document thus communicated we extract the following: "L. Poole, United States engineer, says he sounded down Pass à Loutre, and along the coast of Breton Island, and also for several miles above and below Cape Point Au Sable. The deepest water found was near Cape Sable." He adds:

I come now to the project of an artificial cut from the river to the Gulf. I found near Point au Sable, opposite Breton Island, four fathoms (24 feet) water within three-quarters of a mile of the shore, which is a low sand-bank, apparently unchanging, affording an indication that the sand off this coast is not loose and floating, but hard and firm. About half the distance from the shore to deep water the bottom is hard sand, and excepting a short distance at its outermost extremity, the remaining half is hard mud, forming a hard foundation for heavy walls.

The distance from the Gulf shore at this point to the river, as ascertained by the imperfect means I had for the purpose, is about seven miles, over a marsh intersected by numerous

bayous,* which cover a large portion of the intervening space, but are everywhere very shoal, and presents no important obstacles to the projected work.

An accurate survey of the coast from Pass Loutre to a point ten or twelve miles above Point au Sable, including the corresponding point of the river, and minute examination of the character of the soil to the depth which it is to give the canal, will be necessary to determine the best possible location, as well as to establish the certainty of the feasibility of the project. *It is my opinion that it offers a fairer prospect of certain results, than any other plan that has been spoken of, of opening the Mississippi to ships of the largest class.* A lock at the junction with the river will prevent the deposit of mud in the canal, and the jettees at the sea may be so placed as to form a perfect artificial bastion.

State Engineer George W. Long, esq., is of the opinion, "that dredging out either of the passes would be an ineffectual operation, to improve them, for if they could once be cleared out they would soon fill up again." He "does not know how you would succeed with your canal; if you could make it with a lock, you would find it a difficult thing to secure a foundation, and without one it would be doubtful whether the banks will stand, or not, and on the north side of the Mississippi River there is too much floating sand for a convenient opening of the canal into the Gulf." He thinks that "the navigation of the Mississippi may be improved by obstructing the smaller mouths with heavy booms, well anchored across them, to retain the drift-sand to be conducted into them for the formation of rafts, to break the current, and allow the deposit of the sediment to fill up the channels, and thus ultimately to close up all but but a single pass.

Mr. Fred Wilkinson, Deputy Surveyor-General of Louisiana, "apprehends heavy back water from any attempt to block up any of the auxilliary mouths of our great rivers."—He says:

> The project of a ship canal near, and a little to the eastward of the Pass à Loutre is certainly, from what I have heard from persons acquainted with the subject, a feasible matter, and from the depth of water stated now to exist in the Gulf of Mexico, into which the canal is to open (34 feet,) is highly recommendable. The only objection that strikes me is the enormous expense of the attempt from having to pass through the description of country at the mouth of the Mississippi.
>
> The excavation of the earth consists in throwing out liquid mud, and from the disagreeableness of the situation, every labor requisite will cost, of course, in proportion. A ship canal of only a few miles in length can (including the cost of guard-locks, sets of which, built in the most perfect manner, will be required, both on the ocean and the river) be only reckoned by millions. In case of the ship canal being resolved on, I have no doubt, judging merely from what I have been informed, and not from actual survey, that the neighborhood of Pass à Loutre is, from its being partly land-locked, and sheltered from our prevailing winds, a most eligible location for the same. It is difficult to give a decided opinion without narrow personal inspection of the field of observation, but I presume that building guard boats, a breakwater, and artificial harbor will be requisite in case of the ship-canal being determined on by the Government.

Of this canal improvement Mr. Wilkinson subsequently says that it is, in his opinion, "perfectly practicable," subject only to the objection stated.

Captain A. H. Bowman, United States Engineers, reports that, in his opinion, "the only practicable plan for securing a permanent ship-channel for vessels of the first class to New Orleans is to cut a canal from some point on the Mississippi above its mouth to some one of the arms of the Gulf which approaches nearest the river."

The three last opinions are not vouched for on actual survey by the officers themselves. The most authentic document, based upon and embodying all that had been demonstrated upon the subject to the date of 1837, was the report of Captain W. H. Chase, of the United States En-

* This coincides with the same sounding reported by Gould, a century before, who reports a bottom, along that part of the coast, of sand, and sand with shells.

gineers, predicated upon "a partial survey of the mouths of the Mississippi River and of the line indicated by Major Buisson, State engineer of Louisiana, for a ship canal, all having in view the improvement of the navigation of the said river."*

Captain Chase says: "The obstacles presented to the easy entrance of the Mississippi by vessels drawing 12 feet of water are productive of great injury to the commerce of New Orleans, and require to be promptly removed, or, failing to be done, the construction of a ship canal on the plan indicated by Major Buisson should be resorted to."

"By reference to Chart No. 1 the line of the proposed canal is exhibited, commencing at a point about two and a half miles below Fort Jackson, and extending seven miles to the shores of the Gulf, and thence by a jettee 1,760 yards to 30 feet water. It is proposed to carry into effect this plan of a ship canal."

I. By a construction of a guard-lock at the junction of the canal with the river. The object is to prevent the flowing of the river into the canal.

II. The excavation of the trunk of the canal 100 feet wide at top, 30 feet wide at bottom, and 30 feet deep. The object of such large dimensions is at once to provide not only for the entrance of the largest ships engaged in commerce, but also of ships of war of the largest class. The advantages offering for both classes are obvious and need no comment.

III. The construction of the jettees or breakwaters of large dimensions, having for their base 100 feet, with a depth varying from 5 to 30 feet, and 20 feet wide at top, and raised to the level of high-water.

"The practicability of this plan depends solely on the question, whether a lock of the dimensions required for the admission of the largest sized vessels can be constructed on the banks of the Mississippi. I think the question may be easily answered in the affirmative, for we can to the practicability of excavating almost to any depth in the mud of the Mississippi delta, as exhibited at the several works constructed by the United States, and by individual enterprise. At Fort Jackson, on the Mississippi River, the foundations were excavated to the depth of 12 feet, and were kept free from water by means of a small engine attached to pumps of considerable power. The operations at Fort Jackson, came frequently under my observation, and I left in no doubt as to the perfect practicability of excavating to the depth of 30 feet, and also of the practicability of establishing a solid foundation by piling, for the support of the walls of masonry necessary for the construction of a lock.

"Taken for granted, therefore, that a lock can be constructed, we have only to consider the means of excavating the trunk of the canal and the construction of a shore breakwater. The marsh lying between the river and the gulf, through which the line of the canal is located, is intersected by several bayous, all of shallow depth of water. Commencing at the river, it is proposed to excavate to a depth of 6 feet, affording sufficient water for the dredging machine, which will thereafter be employed in the excavations. The canal being excavated to a depth of 6 feet through its extent.

ESTIMATED COST OF CANAL.

Lock 200 by 50 by 20, the excavation including pumping 24,000, at $1.50....	$36,000
1,000 piles, 30 feet long for the foundation of works, and floor of lock drawn close together at the bottom excavation, at $8.....	8,000

* Report of survey of Mississippi River, 24th Cong., 2d session, Doc. No. 173, House Reps; executor, signed C. Gratiot, Chief Engineer United States, 24th February, 1830.

6,000 yards cubic stone masonry in hydraulic, at $15	$90,000
Cut-stone work for coping, gates, &c	6,000
Gates and guard work on river	20,000
Superintendence, contingencies, including funds for the engineer to adopt any other improvement that may suggest itself during the construction, say	140,000
In the trunk of canal the following dimensions will be required: 100 feet at top, 30 at base, 36,960 feet in length, 2,669,333 cubic yards excavated by steam dredging machinery, will not require the use of pumps, and may be performed for $1 per cubic yard, including cost of machinery and every expense	2,665,333

FOR JETTEES OR BREAKWATERS.

Each jettee will require the following dimensions: 100 by 20, depth 5 to 30 feet, 5,280 feet in length, equal to 205,333 cubic yards for one jettee, for two 410,666—$6 per cubic yard	2,363,996
Channel between jettees *excluding from mouth of canal on the Gulf shore to the entrance of the jettees, 1,000 feet in width*; depth 17½; 5,280 long; 3,420,000 cubic yards excavation by steam dredges under protection of jettees, at $1	3,420,000

RECAPITULATION.

For trade and guard-works	$300,000
Trunk of canal	2,665,333
Jettees or breakwaters	2,333,966
Channel of jettees	3,420,000
Total	8,619,299

This estimate, swelled to $10,000,000 by the caution of this eminent engineer, was at that date a preposterous sum to be applied to any public improvement. The West did not possess the power to pass the appropriation, and the South in its hostility to all such appropriations was divided in its support.

Twenty years later, Mr. R. Montaign, a civil engineer, revived the idea. He based his studies upon the data furnished by Buisson and Chase, and adding thereto a personal examination, which continued for more than six months, produced a plan for constructing the canal by private subscription. In a remarkably able and exhaustive essay he demonstrated that the work was practicable; that its cost would not exceed one-third of the federal estimate, and that, taking the actual commerce of the river-outlet in 1859–'60, the interest account and expense of maintaining the work deducted from the receipts, would leave a net profit of 25 per cent. per annum upon the investment. This plan was indorsed by the merchants and other capitalists of New Orleans, and received the approval of the chamber of commerce, the insurance companies, and the press. The war and the death of the projector defeated this proposal, but, with the restoration of peace, the project of a national canal, as recommended by the legislature of Louisiana, was brought forward, under the auspices of some of the oldest and most eminent merchants. A committee of the chamber of commerce was appointed, which renewed the recommendation of the work, and pressed its adoption upon the Government. In the mean time mechanical skill has greatly reduced the cost of alluvial excavation, and experiment is demonstrating the entire feasibility of the plan proposed. Dredging-machines will do the work, at something like one-fourth the cost of manual labor. Within sixty miles, by water, of the site proposed for this delta canal, another, connecting the river with Lake Borgne, not only demonstrates, experimentally, all questions of construction raised by the earlier commissions, but will in a few months, at the close of its contract, have at its disposal, identically, the dredging-machinery re-

quired for the purpose. A recent letter, addressed to the writer by M. J. Thomson, esq., civil engineer in the service of the State of Louisiana, offers an estimate of the cost of constructing a ship-canal on the ground proposed, of the dimension of 300 feet on the top, 200 feet at the bottom, and 26 feet in depth. After making a careful calculation of the cubic earth-work, which he estimates at 1,271,111 cubic yards per mile, this engineer places the cost of the canal at $500,000 per mile. For the guard-locks he considers $500,000 sufficient; and allowing even a million for the piers, would place the whole cost at about $5,000,000. This estimate might be reduced somewhat, in the opinion of other engineers, who regard the cost of earth-work at less than is estimated. Five millions is, however, a liberal if not an excessive allowance, and yet how insignificant in view of the obligation to be discharged and the interests to be developed.

In addition to the example of canalizing the Delta for a connection with Lake Borgne, we are furnished with a far higher and more decisive model of national emulation. Modern science and capital have renewed the works of the Pharaohs, and completed a canal from the Mediterranean to the Red Sea. This work opens with a deep-water harbor of 400 acres, protected by piers of artificial stone. It is embanked forty miles through the lakes Menzaleh and Ballah, through the high lands El Guisr, with a cutting of 85 feet; then into Lake Timsah, where an artificial port has been constructed; then through the deep cuttings of 62 feet at Toussoum and Serapeum; then, at a distance of ten miles, entering the Bitter Lakes, and passing a distance of twenty miles through a channel marked by light-houses and buoys; thence through the deep cutting of 56 feet at Chalouf, through sands and a marsh, a distance of twelve miles to Suez, where it ends in another artificial harbor. The length of this canal is one hundred miles; its greatest surface is 328 feet; the least bottom width 72 feet; the depth is 22 feet, which is being increased to 26 feet. This work has been constructed through the alluvion of the Nile and the lakes, through volcanic rock, and through the drifting sands of the desert. The power of obstruction of these last may be inferred from the fact, that between Lake Timsah and Port Said, a distance of fifty miles, it is estimated that 1,300,000 cubic yards of sand will be swept into the canal annually. "This will give employment to one of the largest dredges for three or four months, working twelve hours each day." In the year 1869, 1,362 ships of 672,000 tons entered the canal, and this tonnage has been rapidly increasing.

Here, then, we have a work far more extensive than the proposed canal of the Delta. It passes through similar, and also through more formidable formations. It is embanked through lakes, and opens into capacious artificial harbors, formed with artificial stone. It is subject to an obstacle analogous to the sediment of the Mississippi—the drifting sands of the desert.

We will now exhibit the items of—

COST OF THE SUEZ CANAL.

Preliminary surveys from 1854 to 1857	$15,825,525
Administration and negotiations	3,394,245
Sanitary service for 1866 to 1869	121,410
Telegraphic service	34,000
Transportation, boats, buildings, &c	1,644,435
To contractors, for materials	2,442,785
Dredging-machines	6,819,240
Workshops	844,150
Works of construction, canal, &c	43,534,330

Miscellaneous	$1,392,493
Various branches of management	3,843,050
Balance to deepen canal to 26 feet	9,437,560
Total	90,331,223

This gives us an average of $806,936 per mile, as the cost of this canal, with its two ports, estimated at more than half the amount expended for excavation. In conceding this calculation to be correct, we feel authorized to strike out certain items, as inapplicable to the Fort Saint Philip Canal. The general expense of administration of the Suez Canal, and the diplomatic negotiations, are excessive and unnecessary. There are other items which would not cost the United States as much as the corporation of Suez; the expense of preliminary surveys and superintendence would be much less. The delivery of supplies on the banks of the Mississippi and the Gulf coast would be cheaper than upon the shores of the Mediterranean. A pioneer ditch, as on the Mobile and Texas Railroad, would deliver the materials of construction along the whole line of canal without the necessity of employing draught animals for that purpose. The completion of the levee reparations and the approaching completion of the Lake Borgne Canal will place at the call of the Government a large amount of labor, skilled in, and inured to, alluvial excavation, with a number of improved dredging-machines, now employed in performing exactly the kind of work required on the ship-canal.

ARGUMENT.

The capacity of the soundings off the shore of the Gulf of Mexico and through that channel to the sea, is shown to be ample for the passage of any commerce. These soundings are unchanging. A century ago, the British government ascertained and published a chart, which has been verified by subsequent surveys of the United States, and found to be the same. Congress has ordered a survey and reconnaissance of the work, with estimates of probable cost. They will be made during the ensuing fall and winter by the intelligent officer at present in charge of the essayons, Captain C. W. Howell, United States Engineers. This, then, offers an ample and permanent passage and anchorage at the canal outlet. The depth of the river is sufficient at the inlet for all possible purposes. An adequate and undoubted depth of water for the inlet and outlet between the river and the sea is then established—not on conjecture, but upon fact. The first term of a deep-water outlet established, it becomes a proposition of expenditure and science to effect it.

THE FINANCIAL QUESTION.

It is not our purpose to review the mechanical, financial or scientific estimates of the engineer. The duty of the Government and the public necessity for a great work having been established, the details of execution rest with the proper authorities.

With the immense domain and incalculable values locked up within this Mississippi Valley, it would seem a matter of small moment what portions of those values shall be devoted to their development. It may be added, moreover, that when the Government has already expended several millions for the canal around the Des Moines Rapids, and nearly as much more in making the canal around the Falls of the Ohio, it

would be poor economy to refuse the canal from the Mississipi to the Gulf. This will complete the system of artificial relief to the whole navigable length of the Mississippi and Ohio Rivers. Without the Delta Canal to give outlet to the developed products of the West, the enlarged capacity of the upper rivers must fail of its full effect.

But the Government in acknowledging the obligations to keep open these outlets, will naturally seek the least expensive and most certain way of doing so. That mode which insures a vast commerce against obstructions is most economical. Cost what it may, the Government cannot afford to dispense with it. The annual cost of repairing and replacing the vessels employed may be safely set down at $250,000. If we assume the cost of the Fort Saint Philip canal, as stated in this paper, say five millions, the Federal Government need only emit that amount of bonds bearing five per cent. interest, and the amount of interest would be but little more than the present cost. The complete execution of the whole work would save much trouble in organizing an annual expedition against the obstructions, when valuable lives are risked in unequal combat with the elements and the epidemics.

The dredge-boat Essayons has been obliged to interrupt her work during the summer of 1870 from this last cause. There is, however, another reason why those who are especially interested in the outlet navigation should desire this permanent improvement. With the most sincere desire for the preservation of peace, foreign and domestic, with the utmost faith in the disposition of the American people to keep every obligation, we cannot expect to be always exempt from political disturbances which have affected all nations at all times. If the annual appropriation for dredging the outlet should fail or be suspended from any of those legislative accidents so familiar to all, nature nevertheless brings her alluvial tribute and lays it upon the threshold of the ocean, and the people and products of the West are barred of their passage to the world markets. Commerce is suffocated. Who can compute the loss, the discontent, or the disappointment? If, however, the Government shall apply a capital amount of bonds, the interest on which will be not much more than the present outlay, to open the Delta ship-canal in free outlet to the ocean, no accident nor misfortune, no political mishap nor defeat can deprive the great West of a permanent, perpetual, and perfect way of communication with the world. It has been remarked by a sagacious American, of the canal across Suez, "But whether the canal company be a success or a failure to those who have thus far invested their money in it, is of little moment in the world's history. The new route is there; it will remain, and if one set of persons cannot make it pay, then it will fall into the hands of others" This has been already verified.

The Fort St. Philip canal would thus effect an ultimate economy in the annual expenditure of the Government; for it would encourage greatly the importation of dutiable goods in exchange for the developed products of a country otherwise inaccessible to agricultural industry. The West will have a permanent and adequate outlet to the sea, and will receive a large part of the national expenditure, and of its own contributions for that purpose. It must not be forgotton that as the American empire spreads along the slopes of the Rocky Mountains it must pass a point at which the exportation by rail of the cereal crops grown on the parallel of our chief Atlantic cities must become unprofitable. This will be obvious from a single example: The average quantity of wheat grown on an acre in Massachusetts is 18 bushels, worth $1.75 per bushel. The average cash value of an acre grown in wheat is $31.56.

The average quantity of wheat grown upon an acre in Minnesota is 16 3-10 bushels, and the average cash value of an acre of wheat is $9.61. This would make a bushel of wheat grown in Minnesota worth, to the farmer, less than sixty cents. When we deduct from this price the cost per bushel of moving the wheat from the Minnesota farm to the depot, there can be little inducement to its culture, nor can it be carried much farther back, unless some cheaper mode of transportation be provided. We have taken these statistics of production and value from the annual report of the Agricultural Bureau. The same report supplies an appropriate comment in saying: "The continuous planting of new lands of the West with wheat is running west, year by year, the culture of wheat production, and increasing the distance of transportation, while the railroads, by their combination and advance of tolls to secure dividends upon watered stock, are increasing in equal ratio the cost of freights." The quantity of edible grains from west of the Mississippi—including, also, the product of Wisconsin—is about two hundred and fifty millions of bushels. Now, the extent to which the freights upon this product can be reduced, the inducement to emigrants to go upon the immense area of unoccupied territories of the republic, will be increased. The experience, however, of all ports from which grain is exported, shows that vessels of very large burden, of great draught, and of peculiar build are required to conduct this trade with economy. The largest class of vessels trading from Chicago over the Saint Clair flats are of about 2,500 tons, and of 12 feet draught. The Welland Canal only allows the passage to sea of ships of about 600 tons, drawing 12 feet. These figures allow the exportation of cargoes of about forty thousand bushels of grain through the lake outlets. As the increase of draught and tonnage in the vessel diminishes the cost of transportation per bushel, it leaves to the farmer so much more of the price of his wheat in the ultimate market.

WARNING TO THE WEST.

The immense additions to the wealth and numbers of the upper Northwest, the opening of the St. Lawrence river and the Canadian canals in free passage to American commerce, and the rapid development of trade and immigration by that route, point to the rapid organization of a new sectional interest, to be based upon lines of railroad crossing the continent to British Columbia and Puget's Sound, by way of the Red River of the North. The Hon. W. Kelly, in a recent address on the "New Northwest," describes the country intervening between Lake Superior and the Pacific to be fertile and a mild climate. He expressed confidently the opinion that there will be a column of States carried across the continent, but predicts that the largest city on the Pacific coast will be at the Puget's Sound, because of its abundant food, fuel, and its moderate temperature. The tendencies are toward an admission of the Canadas, with a population of four and a half millions, into the Union. With the present political power along the frontier States of the Northwest interested in the Canadian and other routes to Europe, and with the fact that the exports were 23,000,000 bushels of wheat last year by the St. Lawrence, an increase of seventy per cent. within three years past, the *present* West should see the power and the motive to erect the St. Lawrence route into a rival of the Mississippi. What means so simple to enhance the advantages of the eastern routes as by employing the vote or the veto to suspend the annuity for dredging the mouth of the Mississippi? Regard the trade and travel between

the West and the tropical countries. See Baltimore, New York, and Boston competing to supply western products in exchange for coffee, sugar, and other commodities. Is these not reason why the West and Southwest should apprehend indifference, if not opposition, to the direct outlet of the valley? And let it never be forgotten, that with even the cessation of a single season, all the work must be repeated.* The West will not have the power to protect itself forever. Under the present census let its merchants, manufacturers, farmers, and statesmen demand that this natural and indispensable outlet shall be placed on such a footing as that no future inaction or opposition can impair its usefulness.

Why then should not St. Louis, Cincinnati, Louisville, and the whole country that they represent, demand at once the permanent opening of the Mississippi outlet by a canal which can never be closed or taken away?

It will be said that the present mode of improvement by dredging is successful. We take pleasure in stating that the latest report of the officer in charge of that work shows a good broad channel worked out by the dredge to the depth of eighteen feet.† Vessels can now be safely consigned to New Orleans without fear of being stranded on mud lumps. To the dredge-boat now at work on the pass and bars will be added, in January next, a consort. This will insure adequate navigation. We hail this as a temporary measure; it will keep the commerce until a more permanent shall have been executed. It is in fact a scaffolding for the erection of the Fort Saint Philip Canal. We have given the reasons why that work should be preferred to any substitute.

The navigation of the Mississippi cannot be materially enlarged without providing for the reduction of freights.

This cannot be effectually done without enlarging the capacity of the vessels carrying grain to a transatlantic market, and this involves the necessity of opening an outlet channel adequate to carry the large cargoes essential to cheap freights. The Des Moines Rapids Canal and the Fort Saint Philip Canal are, therefore, works necessary to the development of the public domain west of the Mississippi. They are as much auxiliary agents of further sale and settlement, as the railroads based upon public subsidies which traverse it. We will, however, take a more enlarged view of the necessity for this

OUTLET OF AN EMPIRE

The surface drained by the Mississippi exceeds 750,000 square miles, without regarding the fact that the column of States on the eastern slope, in the gorges of the Rocky Mountains, will be compelled to draw their tropical commerce through the Mississippi outlet. The population of this area numbers little less than 17,000,000, upon an average of about 20 to the square mile of the settled portion, a density capable of almost indefinite expansion. To the normal rate of natural increase may be added a large accession of foreign immigrants. This region exhibited in 1869 the following statement of

FOOD PRODUCTION.

	Bushels.
Indian corn	650,000,000
Wheat	180,000,000

* The normal depth of the river will always return. Daniel Coxe, in a work upon the English and French colonies, published in 1727, says: "The Mississippi River has seven mouths, with a depth of fourteen feet on the bar."

† Channel changed by stormy weather, September, 1871.

	Bushels.
Rye	4,000,000
Oats	170,000,000
Barley	14,000,000
Buckwheat	5,000,000
Potatoes	40,000,000
Total	1,063,000,000

OF ANIMAL FOOD

There was received in 1859, at—

	Beef-cattle.
Chicago	403,502
Saint Louis	222,000
Cincinnati, (estimated)	150,000
Louisville, (estimated)	75,000
New Orleans, (estimated)	100,000
New York from Western States	186,000
Total	1,136,502
Hogs packed in the western cities, 1869–'70, (estimated)	4,000,000

This immense product, it must be remembered, is the surplus of live stock held in the country. These are computations of the leading articles of production. They omit wholly the manufactures, whose value may be inferred from the annual productions of the four chief cities of the valley—

Saint Louis	$150,000,000
Cincinnati	125,000,000
Chicago, (estimated)	100,000,000
Louisville, (estimated	75,000,000
	450,000,000

The immense provision product will be combined with the coal, iron, lead, copper, salt, lumber, cotton, and innumerable other commodities which are or may be developed, so that if the export of provisions shall decline, their value will be more than made good in the exportable commodities into which they will have been transformed. Confining ourselves, however, to ascertained products which require an improved outlet to the ocean, we offer the estimate which follows:

TOTAL TONS EXPORTED AND EXPORTABLE FROM THE MISSISSIPPI VALLEY.

	Tons.
Cotton	350,000
Tobacco	36,000
Grain	2,000,000
Other provisions	120,000
Total	2,606,000

Here then is a probable commerce that far exceeds that of the Isthmus of Suez at present. Will our Government hesitate to give five millions, when individuals have subscribed a hundred millions for a similar work in a foreign land?

These figures omit much detail of authentic statistics. They may appear startling, but they are true. When we reflect that this vast area has only been subject to the control of intelligent man for about three-fourths of a century, and note its prodigious increase of wealth, population, and progress, no estimate can be excessive. When Mr. Burke, in his great and unavailing effort to preserve the British Union, would have impressed upon the nation the vast growth of the American colonies, he supposed it would appear to many incredible. He therefore

said that the growth of the colonies was so that even if the estimate should be in advance of reality, "while we pause to make the figures, the fact is upon us;" a pardonable hyperbole equally applicable to colonies of those colonies. Our statistics grow stale even while we expose them to inspection.

We ask every American legislator, is not such an empire, with such inhabitants and such resources, capacities, and destiny, entitled to a commercial connection with the outer world? Is not the standard of civilization in literature and the arts in Saint Louis, Chicago, Cincinnati, New Orleans, sufficiently high to justify these people in demanding facilities of commerce equal with any other portion of the republic? Shall a people who pay two hundred millions of annual taxes toward the support of the common Government, be denied a highway to the sea at a cost of the annual interest on their contributions? They have ceded to the National Government the right of taxation upon imports, the natural fund for removing physical obstructions to commerce. They have yielded the paramount jurisdiction over their natural highway to the ocean. This great highway and outlet was given them by the law of nature and of nations. It has been guaranteed against hostile obstructions by the valor of the people who inhabit its shores. Shall this great highway, which neither foreign nor civil war could obstruct, be shut up by an accummulation of mud? Shall these vast values be incarcerated from market for the pittance necessary to relieve and deliver them? For such services and for such contributions, for such right and undeniable right and obvious policy, is any appropriation excessive or unreasonable?

DISTRIBUTION OF THE EXPENDITURE.

In the application of the money asked for the construction of the Delta Canal, every dollar may be paid to some important domestic interest. The workshops and ship-yards of the North and West will supply the engines, dredge-boats, implements, with the food, coal, and animals. The Southern States will furnish much manual labor. New York and New Orleans will conduct the financial administration. As every part of the Union will pay its quota of the cost, every part will participate in the distribution of the expenditures. Not only will the construction of the work promote the interest of all, but it will add to the strength of the republic by removing a cause of sectional discontent. This consideration comprehends a value not to be computed in money; it has sometimes cost millions in its consequences.

The Federal Government should not limit its aid to the specific work under consideration. It should adopt a policy by which all impediments to the navigation of the main stream of the Mississippi will be removed. It is a natural highway, governed by national authority in its whole navigable length. This duty of the Government may be most effectually performed by canalizing the main branches at the Des Moines Rapids, the falls of the Ohio, and the Muscle Shoals of the Tennessee. The ship-canal at Fort Saint Philip will complete the system.

The West should moreover impress upon the President his promise to revive the trade treaties with Spanish America, and insist on the same liberal reciprocity in regard to their commerce with the Mississippi Valley as has been granted by England in regard to the Canadas. If the great West is at this moment guaranteeing and guarding the sovereignty of Spain over Cuba, and the integrity of Mexico, Colombia, Venezuela, Chili, and Peru, against European aggression, there should

be some compensation in the facilities of trade with the United States. The same may be said in regard to an equalization of the postal subventions connecting the Mississippi Valley with all the principal foreign ports to the south of New Orleans, on this continent. These vital issues should be embodied in the platform of every western political convention; they should be insisted on by all candidates of all parties for the Presidency or for Congress.

We bring this extended memoir to a close by enumerating the measures proper for adoption by Congress in compliance with a national duty.

1. To require an immediate report from the proper department of the Government upon the practicability and probable cost of the Fort Saint Philip Canal.

2. To direct the construction of such canal, if deemed expedient, by contract with responsible contractors.

3. To appropriate an amount of Federal bonds which will nett, in market, the sum necessary to construct the canal and ports.

4. To include in the appropriation for the annual operations for improving the mouths of the Mississippi River a sum sufficient to meet the annual interest on the capital cost of the canal as well as for superintending and keeping the same in repair.

C.

Project of a ship-canal between the Mississippi River and the Gulf of Mexico, by R. Montaign, civil engineer.

INTRODUCTION.

Of all the elements which enter into and affect the value of commercial products, none has made more progress toward amelioration, during our time, than the question of mode and means of transportation. This truth needs no further proof when we remember that we have seen the inauguration of railroads and steam navigation. This extraordinary development in the means of communication was commanded by the first of all social necessities, that of relations and exchange. The prosperity of a country is in proportion with the extent of its sphere of expansion. The creation of a great commercial road, by land or by sea, causes rich and populous cities to rise from the soil, and former queens of commerce see life and motion leave them and take another direction, if some new road is inaugurated which overthrows the long-established habits of trade, and diverts them from their ports.

No question, then, can present greater importance for the prosperity, and even the existence of a great commercial mart. It must tend to increase constantly the extent of its circulation by the creation of new means. It follows, therefore, naturally, that its first duty must be to keep in order and improve those means which it already possesses. Such is at present the position of New Orleans.

Commanding the greatest of rivers, she sees the productions of the vastest agricultural valley that exists brought daily at her feet; these unique advantages, which she owes to nature alone, insure her a prosperity unrivaled and boundless from the day she will choose to develop them by her industry and her activity.

But to this nature has attached a condition. In establishing New

Orleans as the queen and mistress of the Lower Mississippi it has imposed on her the duty of making the access thereto easy, sure, and constant. She owes the fulfillment of this condition to the whole commercial world, for, from the day that transportation through the mouths of the Mississippi River would become too burdensome and onerous, freights would have to take another and less direct route, and the commerce of the Old and New Worlds would receive a fatal blow.

But the first consequence of this perturbation would be the complete ruin of New Orleans and the division of her profits among certain other commercial centers, possessing perhaps less natural advantages, but gifted with more wisdom and enterprising activity.

Yet it is to this result we are marching rapidly, and we cannot even plead that we have not been warned in time. Science, men of experience, seamen and merchants, the facts themselves, have fully demonstrated beyond the shadow of a doubt that the Mississippi offers no longer to our vessels an immediate easy and safe access; that between the mighty river and the sea a wall has arisen, increasing every year; that while it would be indispensable, in order to reduce the costs of transportation, to introduce in our great cotton mart the use of ships of the largest tonnage, it has become necessary to construct, specially for the New Orleans trade, vessels of middling capacity, in order that they can surely cross the bars that obstruct the entrances to the river.

In presence of such facts, and in presence of the formidable competition which the North and East are making to draw to their markets the productions of the Upper Mississippi, we can foresee plainly the day, not far distant, when our great port will only be occupied by the coasting trade and opened to the navigation of smaller crafts; when commerce will have taken another route; when our merchants and shippers will see the productions of foreign countries reaching them only through northern or eastern channels. Then, New Orleans will have passed from among the great commercial cities of the world.

Are these dangers so imminent? This is what our deplorable indolence has, to this day, refused to convince. It is in vain that official reports, the complaints of ship-masters, the losses suffered by shippers, the dissatisfaction of consignees, the losses paid by underwriters, have clamored to our ears like so many alarm bells. We are loath to suppose that the prosperity we have so long enjoyed can cease, and as long as ships arrive at our wharves, at whatever cost or condition, we remain slumbering in treacherous security.

There is, besides, an excuse to be found in the difficulties of the question itself. The most judicious minds who agree that something must be done, cannot come to any conclusion. Scientific men do not agree as to the origin of evil. Practical men do not agree better as to the proper remedy to be applied. There is only one point on which all unite, that it would be necessary to undertake a struggle against nature itself, the result of which must be doubtful, expensive, and of short duration. However, it will admit that this is no reason why no action should be taken, and that if the question cannot be solved directly by open and bold measures, there may still be some other means to arrive at a solution. This we come to proclaim openly.

Yes, the danger is so imminent that not one instant should be lost, not to repair the harm already done—that is beyond the power of man—but to free ourselves from its future consequences. Yes, something can be done; something simple, logical, decisive. Thus to prove indisputably that the powerful hand of nature closes the mouths of the river to commerce, and that far from having the power, by any effort of

science, to conquer this obstacle, we tend to increase it every day by necessities of another order, such as the consolidation and raising up of our levees, will be the first part of the task we have undertaken.

To substitute to this opening which escapes us, another wide, easy, practicable at all times, free from all the inconveniences of the present passes, and from all danger of closing itself subsequently, such will be the second part of our task.

The double demonstration, if we prove adequate to the important task we have had the honor to be intrusted with, contains the salvation and future of New Orleans.

PRESENT AND FUTURE CONDITION OF THE PASSES.

It would be extremely to make a retrospective study of the former condition of the Mississippi, and the importance of the deposits that obstructed its bed during the early times of the colonization, or even until our time. Official information on this subject is completely wanting. The able State engineer, Mr. Luis Hebert, said in his report of 1850:

> We are still quarreling among ourselves, to decide by words and by arguments founded on conjectures, what the Mississippi was, what it is, and what it will be. Our knowledge of the past rests on facts gathered here and there, partially in one year and partially in another; now by this person, then by another—incoherent facts, disjointed by time, localities, and circumstances.

In presence of such declaration, the scarcity of anterior documents and the contradictions they contain, are no more surprising than the antagonism of opinions on actual facts, for in such matters certainty can only be based upon a long series of connected and systematical observations.

Thus, on one side, one of our most distinguished hydrographers, Dr. Cartwright, states positively that the bars at the mouth of the Mississippi have not increased, as it is generally believed, but have remained the same since one hundred and forty years, excepting changes in the direction of the passes and differences of one or two feet in their depth, the effects of winds and tides. On the other hand, we find data in old works on this subject stating that, in 1722, there was 25 feet of water on the bars, and that this depth was reduced to 20 feet in 1767. In our days the depth is only 15½ feet, as shown by the last soundings made by Engineer Hebert, and more recently by myself.

It is certainly much to be regretted that a greater number of observations cannot be gathered, which would enable us to determine and discuss the law that governs this gradually increasing obstruction, but it is, nevertheless, safe to affirm that the established natural tendency is a progressive diminution of the depth of water on the bars.

Another fact resulting from an examination of the past is the continual lengthening of the delta of the Mississippi in the Gulf. Comparing the exact soundings made by Captain Talcott, United States engineer, in 1838, with those made by the same gentleman in 1851 and in 1852, we find the deposits of alluvion advance seaward at the mean rate of one mile in every 15 years, which represents a progress of 350 feet annually.

Passing from the data found in the past to an examination of the present, we draw from official sources the following description of the Mississippi and its mouths in their actual condition:

After running a distance of five thousand miles from the Rocky Mountains, with a mean inclination of seven inches per mile; after crossing a basin two thousand five hundred miles in width, and presenting a surface of one million one hundred and twenty-three thousand one hundred square miles, the Mississippi flows in a single and majestic channel to within ten miles north of the twenty-eighth parallel, where the river divides itself in three branches: One, following the axis of its first direction, meanders until it empties in the Gulf of Mexico. It is the South Pass. Another inclines 35° westward. It is the Southwest Pass. The third branch is no less than the principal channel, which, relieved by these two large outlets, changes completely its direction. Coming from the northwest, it inclines eastward from the English Turn, making an angle of 125°, and continues in this new direction until another subdivision takes place, a portion of the mass of water flowing southward, forming at the Balize the Southeast Pass, the remainder continuing eastward, inclining somewhat toward the north, and forming the Pass à Loutre, or Northeast Pass.

Thus, in reality, the river has four outlets to the sea, but only two interest commercial navigation. The South and Southeast Passes are already too much obstructed to be hereafter counted as regular outlets.

We will therefore confine ourselves to describing the Southwest Pass and Pass à Loutre.

Here is what Mr. Hebert, the State engineer, says about the latter:

> The bar at Pass a Loutre has only a width of 250 yards, and the channel across the bar is 200 feet wide. A mass of mud in the center divides this channel in two. The most narrow has only a depth of 12 feet; the other is wide enough to give passage to a ship and two tow-boats, and has a depth of 15½ feet. The channel is nearly straight, and with the exception of the elevation in the center and of three others on the side, is free from obstructions. The bottom seems to be of the same nature as that of the other pass, sometimes hard and sometimes soft. The direction of the channel is such that ships can sail on the Mississippi from English Turn, with prevailing winds, during eight or nine months of the year. This would relieve them of the expense of towage.

As to the Southwest Pass, it had, in March, 1858, 15½ feet of water in the channel at mean tide. The bar is one mile wide, and the channel quite narrow and crooked. Mr. Hebert calls "the channel" that which has the greatest depths; for the bar is cut in all directions by holes and small channels.

Such are, at this day, the two principal outlets of the greatest line of interior navigation in the world. We could prove this description to be faithful by multiplying quotations; but we deem it sufficient to warrant the conclusion that the Mississippi has, properly speaking, no reliable open outlet to the sea. Theory, as well as the experience derived from the many attempts made or projected, will demonstrate that the Mississippi can never, at any cost, have such an outlet or mouth.

There are two opposite systems to explain the formation of the bars, and each of these systems is erroneous by its exclusiveness; for both are true to a certain extent.

One of these systems attributes this accumulation to the deposit of the immense masses of matter carried along by the turbid current of the river, which is necessarily precipitated when the force of the current is destroyed by its junction with the sea; this is the old or fresh-water alluvium theory.

The other system denies that the river has anything to do with this accumulation, and explains it as altogether caused by the action of the sea; this is the modern theory of bottom waves. The sea continually

tears up its shores, and, under the impulse of winds and currents, the fragments washed away by the waves are carried to enormous distances. When the waves strike against an obstacle, the speed decreasing and even disappearing entirely, the sea abandons all the solid parts it carried, and these sinking to the bottom, form shoals and accretions. When the obstacle happens to be a stream, this deposit forms a bar at its mouth.

In the excellent work of Linant Bey and of Mongel Bey, on the Isthmus of Suez, we find that operation described, as follows:

The carrying power of the sea depends upon the size of the tides and the direction of the winds, as also of their intensity combined with that of the currents which are found in all the seas. Thus while considerable masses of matter are set in motion along the sea coasts, the rivers, and particularly those of a great length, only carry to the sea muddy matter of so little weight that it is carried afar and deposited in the depths of the sea. We have a remarkable instance in the river Nile, whose waters, at the period of inundation, can be distinguished from their peculiar color, at a distance of more than ten leagues at sea. All the accretions and shoals up to eighteen miles of its mouth are muddy, while all the bars at its mouth are composed of sand.

The obstacles at the mouth of the Nile, therefore, proceed evidently from the sea. To demonstrate this with still more certainty we will quote the reasoning of the engineer, Bonnicean, in regard to the alluvium in the river Mersey, in his excellent work on the navigation of tide rivers:

If the accretion came in any sensible degree from the highlands, the quantities deposited from time to time ought to be proportionate to the quantities of rain which fall during the same periods; for the volume of matter brought down from the highlands and carried by the river must be regulated in a great degree by the quantity of water that carried it. But it is a well-established fact that the accretions of sand to be found at the mouth are so much greater when the volume of water is smaller; while in high water time, when the Nile contains nearly 0.008 of suspended matter, the sand banks are carried off and distributed a great distance at sea.

We have quoted at length in order to demonstrate at the same time all the force of this system in certain circumstances and its insufficiency in others, particularly in what concerns the Mississippi.

To prove that the system of the formation of bars by the carrying of marine detritus is insufficient to give us satisfactory explanation of the difficulties which surround this vexed question, we have only to remark that the action of the Mississippi is directly opposed to that of the Nile. It is during the season of rains and high tides, when the river carries 1.1153 in weight of matter in a suspended state, that the deposit on the bottom and upon the bars is greatest, which could be easily forseen, and is clearly explained by the system of fresh-water alluvium. It is at the time when the difference between low-water and high-water marks is fourteen feet, in the city, that the bars are most difficult to cross.

As to the carrying away of the bars by a confluent volume of water at high-water mark and their scattering in the sea, it is a question far from being raised.

On the other hand it is evident that if the accretion of alluvium was caused exclusively by the Mississippi it would take place from outside to inside the bar, and would tend to extend against the current of the stream, instead of advancing progressively seaward; as, approaching the bar already existing, the current would lose its swiftness and would allow its muddy load to settle inside of the obstacle. Besides, the geological soundings made by engineers of the United States through the sedimentary accretions of the bars have demonstrated the existence of four or five evidently distinct strata, the origin of which runs back to regions of the Gulf, far from one another. Thus one is disposed to recog-

nize in the bar at the Northeast Pass, or Pass à Loutre, alluvium proceeding from the Alabama River, and the sands of the Rio Grande can be identified in the strata obstructing the Southwest Pass.

From these apparently contradictory arguments we may infer that these two causes, the river and the sea, concur to form the mouths of the Mississippi, each in its respective limit, and to leave only one principal outlet, perhaps sufficient as an issue to its waters, but too much restrained and irregular for the necessities of an extensive navigation. These two equally powerful causes do not balance each other at any given time. Each has its period of weakness or energy.

The river in ordinary circumstances, that is to say, at low-water mark, or at mean tide, carries a certain quantity of matter, which is distributed in the depth of the liquid mass according to its density. The finer and more diluted mud being nearer the surface.

The swiftness of the current near the bottom being much less than the swiftness of the upper current, the deposit in the bed of the river of all the heavier matter takes place especially when the current approaches the eighty-feet wall which forms the main body of the bar, leaving only an outlet of fifteen or seventeen feet above it. In this outlet the water increases, being compressed and undergoing the same pressure, it obeys the laws which causes the contraction of the fluid veins. It is not then, therefore, that it deposits the light mud with which it is laden, but carries it out to sea a distance of several miles, and a wide circle indicates the limit where this mud ceases to color the water, and where the sea, after dividing it into minute particles, spreads them afar under the action of winds and currents.

Mr. Charles Ellet recognized at sea the existence of a stratum of fresh-water, about 7 feet in depth, floating in the waters of the Gulf without mixing with them; and this phenomenon of two distinct currents manifests itself on the bars, where it is ascertained that under the columns of fresh water there is a counter current of about 8 feet of salt water. This new narrowing of the outlet corresponds with a new increase of swiftness, for while the velocity of the river is only 2,6 inches at Carrollton, it runs at a rate of three miles at the surface, and nearly two miles near the bottom when passing over the bars.

The existence of this under current combines with the increase of swiftness we have alluded to, to render impossible any fresh-water accretions during the mean or low-water mark. Then, during this period of mean and low-water, the river carries to the sea all the alluvium the density of which has prevented their deposit in its bed before reaching the passes. Nothing remains on the bars.

It is no longer the same at high water. Then the outlet is no more sufficient, the river drives the counter current before it, and its waters occupy the whole passage. But, as its increased swiftness has enabled it to transport more numerous and voluminous materials, these, detained in their course by the friction on the bar, and by the resistance of the sea, settle on and obstruct the bars. Meanwhile the upper current of the river, whose velocity has not been reduced, carries afar in the Gulf all the lighter alluvium, which it there leaves to settle in the depths of the sea. If while this pressure takes place in the fluid vein a strong tide or a storm should drive the sea against the pass, the struggle between the sea and the river current trying to force an issue, plows up and drags away the matter which had deposited itself horizontally on the bar; it disturbs it and occasions accidental obstructions at high-water mark, and gives birth to those singular phenomena known as mud lumps.

If the river, during its rising period, partially builds up the bars, either by extending them inward or by adding to their height, the sea regains its superiority during high-tides or great storms; for it piles up new materials at the base of what already forms the outer wall of the bars. These materials are thus, in great part, restored to their former origin; for the greater portion consists of alluvium that the great river had furnished, and it is fortunate that such should be the case. The argillaceous nature of these materials prevents the accretion formed from attaining too much consistence and resisting the causes of destruction or removal to which they are exposed.

Fortunate would be New York if the vast sand bank which is gradually invading its port was of a nature so little resisting.

This double and irresistible action of the river and the sea, which we would describe more minutely if it would not lead us too far from our subject, follows and obeys an immutable law of nature, to attempt to change which, by any contrivance of man, would be folly; for the more closely we study its working, the more convinced shall we become that its field of operation is too vast, and must increase rather than remain stationary.

The gradual growth of the obstructions at the mouth of the river, previously referred to, has been and still is accelerated, if not entirely caused, by the system of levees as now practiced on a yearly increasing scale. This system has prevailed over the system of lateral outlets, and, without wishing to discuss at present the wisdom of that preference, we make note of it, and only remark that the mass of alluvium which formerly deposited itself in accretions on the swamps of the delta now go entirely to the sea. This is doubling the volume of fluvial matter which drifts into the sea; it is, therefore, doubling the materials with which that indefatigable builder will erect the walls of our bars.

On the other hand, as the delta projects itself further out the various mouths of the river are left every day more exposed to the action of the winds and currents without protection. It is admitted that any great river that does not empty into a bay capable of protecting its mouths against the action of the winds and waves must soon be obstructed by the formation of bars heaped up by the sea. Such has been the case with the Ganges, the Nile, the Mississippi. It is even necessary that the surface of the bay should be, to a certain extent, proportionate to the volume of water which is discharged in it; if too small, the river does not lose a sufficient portion of its swiftness, and comes out of the bay still exposed to the contrary influence of the waves; the bay in that case is but an enlarged outlet of the river.

If the bay is too wide the swiftness of the stream is quickly reduced, and its sedimentary deposit fills up gradually the basin in which it discharges itself. Such is the case with the river Clyde. Some hydrographers are of opinion that the vast bay formed by Lakes Borgne and Pontchartrain, and yet called the "Mississippi Sound," was destined by nature to be the real outlet of the river, and that, by closing the outlets of its waters in the two reservoirs above and below the city, the natural course of this navigable highway has been completely changed.

Whatever may be the case, the progressive tendency of the delta toward the sea will only increase the encumbering and obstructive influence of the winds and currents. The South and Southeast Passes, henceforth impracticable for ships of ordinary draught, prove that, where this influence is direct and in the course of prevailing winds, its effects are alike prompt and dangerous. The North and Southwest Passes have thus far escaped this action, only because they have been partially protected by their peculiar direction.

Consequently, nothing can be hoped from the natural agents, either in the present or future condition of the mouths of the Mississippi. Far from it. We have demonstrated that this condition can only grow worse in the course of time.

Let us now discuss the efforts that have been made to undertake a gigantic struggle against forces that are natural, eternal, and necessary. We will embrace in the same examination the study of the means indicated, but not tried. We will find the result of this examination in the conclusions of the State engineer, Mr. Hebert:

> Let us submit ourselves not to struggle with the Mississippi. We have no hold over it. Our presumptuous efforts can only result in bringing the punishment on our own heads.

The slightest reflection on what procedes will enable any one to understand that the idea never entered the mind of any practical man to remove and annihilate those immense masses called bars. Let one imagine enormous blocks of mud, having a length of several miles, a width varying from one-fifth of a mile to one mile, and a height of more than eighty feet. Let them be represented propped on the river-side by an abutment which is formed by its bed, upon which the deposits of ages in the untroubled waters have caused such elevation of that bed that its height is eighty feet more than any other point as far up as Baton Rouge, although the mean declivity of its surface is 3¼ inches per mile between these two extreme points. In presence of such gigantic obstacles it will be easily understood that all the hope of science and commerce has been limited to the excavating of their upper surface in order to procure an open and permanent way to navigation. Consequently a regular passage of from 3 to 5 feet more depth than actually exists on the bars, is the extreme height of the ambition of our engineers and our merchants. But, as modest as may be this ambition, it is necessarily doomed to disappointment, for a sort of compromise has been entered into between the sea and the river, by the slow and alternate poising of their opposed forces, by which the necessary outlet for the river has been fixed at a height of 15 to 17 feet; we cannot go beyond this.

The first work for the improvement of the passes goes back as far as 1839. The Federal Government commissioned Captain Talcott, of the Corps of Engineers of the United States, to proceed to the opening of a regular channel. That officer used in his attempt the ordinary bucket-drag; but circumstances were so unfavorable that he obtained no result. In one stormy night twice as much mud was thrown into the Southwest Pass as had been taken away after these expensive labors.

In 1852 the Federal Government made with the Tow-boat Association a contract for the opening of the passes. This contract was fulfilled and the work executed in twelve months. The means used by the association were the harrow and the rake, and the result was successful beyond all expectations; a channel was dug 18 feet in depth, and on a length of one and a half mile. This process had already been successfully adopted on several alluvion rivers in England.

As, after this result, no ulterior measure was adopted by which to maintain the Southwest Pass in this prosperous condition, and the causes of the formation of the bar not having ceased to act, the bar naturally very soon became as impracticable as ever to navigation. It was again a dreadful storm that destroyed the work already accomplished.

A new effort was attempted in 1856, but upon an entirely different principle, and based upon a theoretical conception. The Corps of Engi-

neers of United States thought that, if it were possible to give the river a greater velocity in the locality of the bars, the deposit would be swept off far away, and the passage would remain free, without any necessity for periodical and expensive labors. This solution corresponded with the hypothesis of the formation of the bars by the immediate precipitation of the fluviatile alluvium, without taking in account the action of the sea. In consequence, Messrs. Craig and Right were authorized, by a contract with the Government of the United States, to open a canal, 300 feet wide by 200 feet in depth, in a straight line across Southwest Pass, and a similar canal across Passe à Loutre. The work in both passes was to be completed in ten months. The contractors were, besides, bound to open these channels during four years and a half, to begin from the completion of the work. Subsequently the contract was amended by reducing the required depth of the channels to 18 feet instead of 20, and by granting an extension of time.

The plan prescribed to the contractors was the closing up of all the passes, except the Southwest Pass and Passe à Loutre, and the contraction of the current by means of oblique dykes, made of strong piles placed at a distance of 5 feet and connected by boards 4 inches thick, with crowning boards connecting the heads of the piles to one another.

The work performed in Pass à Loutre began on the north side and extended itself in a diagonal line in the current to a short distance from the bar, and on a length of 550 feet. In the Southwest Pass this breakwater was not over 3,000 feet in length. These enormous expenditures gave no result, and the contractors had to give up the work. But even had a result been obtained, it could only have been temporary, like everything else that has been attempted to modify the condition of the passes.

The problem of the outlets of the Mississippi had been assimilated to that of the mouth of the river Clyde, where a breakwater made of stakes supporting a stone-work had given excellent results. The assimilation was incorrect, inasmuch as the Clyde is protected at its mouth against the action of the waves by the firth, in which it empties, and that the only cause of its accretion was the too great extension of the firth, as compared to the volume of water proceeding from the river, which arrested its swiftness and determined the precipitation of the deposits. We will observe, besides, with Mr. Hebert, that any wood-work placed in the waters near the Gulf would be destroyed by the worms in a few years.

After this fruitless attempt the contractors created, during some time, a navigable channel by employing the expensive process of blasting. But all this was again made useless by the incessant but silent working of the forces which cause the formation of the bars, and Messrs. Craig and Right had to abandon definitely their contract.

Since that experiment, all the science of the engineers who propose to improve the bars is confined to the drag to break up the accretions and carry them out to sea, or to the use of the harrow, to disturb them, confiding to the current the task of carrying them out. In both of these systems, so little different from one another, it is well understood that this work can only be made permanent by means of an annual fund created for this ever-recurring task.

Captain Duncan's consists in the purchase of a dredge-boat, costing $50,000, and operating successively on the two bars during four months each. The calculation of the cost attendant on this work shows, after deducting the cost of the boat, the net sum of $105,270.

Mr. Hebert opposes this plan for various reasons, which are well worthy of attention:

"First," he says, "this work would demand heavy expenses for boat and machinery; and when the mud will have been detached from the bottom it will have to be put in other boats which will carry it out to sea. Many laborers will be needed and the process will be very slow. Secondly, while these boats will be employed in the channel they will incumber it in such a way that ships will not be able to pass, and commerce will suffer."

Mr. Hebert's plan, which is based upon the use of the scrapers and the harrow, has not, he thinks, those inconveniences. We cannot agree with him on that point; for the two boats he proposes for the two passes and the management thereof, we find, again, an expense of $150,000 will have to be renewed annually. The difference for such an object is not much. As to the presence of a boat in the channel, it seems to us equally troublesome in either system.

But what induces us to embrace both in the same condemnation is the judgment passed upon them by the facts we find in the past. Was it not the drag that Captain Talcott used in 1838 and 1839? A night was sufficient for the destruction of all he had achieved. Was it not by means of the harrow that the Tow-boat Association opened a temporary passage? A single storm sufficed to fill it anew.

Can nothing better than such uncertain and feeble results be obtained in this enlightened age, for the security and benefit of the immense commerce entering into and issuing from the Mississippi—a commerce already counted by hundreds of millions of dollars, and destined, with proper facilities, for the safe and speedy entrance and departure of vessels, to vie with that of the largest ports of the New World in richness and extent? We believe there can; and we shall proceed to examine whether an outlet from the Mississippi cannot be obtained by means, and through a way more sure and durable than any that have yet been proposed.

All the investigations hitherto made convince us that we are powerless to improve permanently the outlets of the river, either by acting directly on the passes or by modifying the general course of action of the river itself; and we are again and again compelled to admit that the Mississippi has not, and cannot have, a reliable, adequate outlet at the extremity of its course.

Before we attempt to create another, let us examine the consequences of this proposition on the commerce of New Orleans.

NECESSITIES OF A COMMERCIAL OUTLET TO THE MISSISSIPPI.

The free navigation of the river by ships equal in size to those which frequent and supply all great ports—that is, of an average tonnage of 1,000 to 2,000 tons—has always been the hope and the dream of the commerce of New Orleans. The numerous failures experienced have not yet destroyed that hope, nor have the sad lessons of reality been sufficient to dispel the dream. This illusion has, however, cost dearly to our port. Our commercial navigation offers the singular anomaly of one of the greatest foreign exportation trades on a distance so considerable as the width of the Atlantic, carried on by means of small ships, whose average tonnage does not exceed 692 tons. We will have occasion soon to refer to the deplorable consequences of this singularity.

If at the beginning of our great commercial enterprise which does not go back to a very remote date, public opinion had been as determined as it is now, concerning the impossibility of opening the mouths of the Mississippi to the navigation of large vessels, the force of circumstances, the encouragement found in the admirable condition of our

port, and urgent necessity, would have induced the founders of this community to adopt, at an early date, the only measure that reason points out, and which we want to attempt now. *They would have left aside the passes, and would have a direct outlet from the river.* For the last forty years New Orleans would have been the first port of the United States; New York would have only occupied the second rank. It is not too late to open our eyes to truth, and to act with energy and promptness, no longer to conquer anew a rank that has escaped us forever, but to avoid the consequences of our former and fatal errors. It is no longer the question of glorious predominance, and of a rank to be assumed. The question is to defend our existence, and to preserve for our wharves the produce disputed by unrelenting competition. Our rivals act and create; as for us, we are content with making official reports on the subject, and when these reports uniformly conclude by an appeal to Congress, we wait, with our looks turned toward Washington City.

Previous to the war with England, New Orleans had not awakened to her great commercial existence; the greater portion of her commerce found a channel through Lake Pontchartrain and Lake Borgne. When for the defense of the country it became necessary for the Federal Government to close those two outlets of the river above and below the city, nothing was left to the latter except the way by the passes. At that early time the clever speculators of New England understood the immense benefits which a navigation that could only be performed through countless shoals, through a maze of reefs whose positions vary incessantly, and where the use of a great auxiliary power was indispensable, would promise to a piloting and towing association. Thus it was that the burdensome exigencies of pilots and tows were imposed upon our newly-born commerce. However, the hope existed even at that date that the yoke would be thrown off the day when great works will open forcibly the mouths of the Mississippi. It was necessary to submit to this for the time being, and to conform to it the condition of the commercial navigation. Meanwhile navigation in large vessels was abandoned and ships of small draught were constructed expressly for New Orleans.

At last came these attempts at improvements so long promised and so impatiently expected. We have seen that they go as far back as 1839, and we have narrated the useless labors of Captain Talcott. During that time the deplorable condition of our navigation called from the shippers of the interior, from our own and foreign merchants, such numerous and energetic complaints that they suggested the idea of a possible competition. This consisted in nothing less than to build, at great cost, railroads on all the width of the continent to meet the Atlantic ports, whilst the great river, "that moving road," as Pascal calls it, was gratuitously left to us. Moreover, the greater portion of the articles which would have been carried upon these railroads consisted of agricultural products of a comparatively small value and cumbersome nature, for which the question of rapidity was immaterial. It must be conceded that all these motives made the prospect but little encouraging, and that it needed all our infatuation to permit a success so doubtful to all appearance.

Notwithstanding the incomparable superiority of the Mississippi over all other practical routes, the railroad system began to draw an important portion of the produce of the Valley of the Mississippi. All the North and a portion of the centre belongs to them; it is by a net of railroads and by the navigation of the great lakes that the grain from the West and the Northwest, the most collossal mass of agricultural products ever thrown into circulation by any country in the world, finds an issue. The

time may yet arrive when we can again enter the lists and bring back to its natural route a certain portion of this immense tonnage. This will be when we have a secure outlet for the river with a constant depth of water of 22 to 24 feet, together with a direct communication with Europe in ships of considerable tonnage. To obtain this result so easy, since it only depends on our own will, it is necessary that the community should be thoroughly enlightened upon the present condition of the commerce at the mouths of the Mississippi and the consequences to the prosperity of our city resulting therefrom.

We cannot quote in this respect a more instructive document than that we find in report of the committee of the New Orleans Chamber of Commerce, commissioned to visit the bars in February, 1859. This committee was composed of Messrs. W. Creery, E. L. Wibray, J. B. Morrison, G. A. Fosdick, and P. H. Skipwith.

The amount of merchandise delayed at the bar on that occasion, seeking ingress or egress, was estimated as follows:

1. *For exportation.*

Cotton, bales, 71,985, at $60	$1 319,100
Tobacco, hogsheads, 3,337, at $150	500,550
Sugar, hogsheads, 2,277, at $75	170,775
Molasses, barrels, 1,575, at $12	18,900
Pork and beef, barrels, 11,309, at $18	203,562
Flour, barrels, 11,417, at $5	62,793
Lard and ham, tierces, 2,929, at $30	87,870
Wheat, sacks, 3,789, at $1	3,739
Total	5,367,339

2. *For importation.*

An approximation of value	2,000,000
	7,367,339

It will be thus seen (says the committee) that there is now held in check, in consequence of the impediment to navigation above referred to, property worth nearly five and a half million of dollars, the interest of which for a single day, at 6 per cent. per annum, amounts to about $1,000. In this estimate no account is taken of the value of the ships, nor any but the leading articles of produce; nor the cargoes of the ships which have cleared and are ready for sea, and whose commanders deem it more prudent to remain at the wharves until there is a prospect of getting over the bar without difficulty, than to lie at anchor inside or aground on the bar in the crowd of ships, and liable to damage. This is a startling array of figures; in itself sufficient, in the opinion of your committee, to arrest public attention and cause the most indifferent to reflect on the evils likely to arise from such a derangement of the commerce of the city, and which will end in the total ruin of our trade, and even our very existence as the emporium of the Southwest, unless prompt and energetic means are adopted for the removal of these obstructions.

Much has been said and written on the subject of the railroads which now tap the Mississippi River, and have their termini on the Atlantic shore, and of the injury which they are likely to work to the trade of New Orleans, by diverting the produce of the great valley of the Mississippi from its natural outlet there: but these your committee have read and listened to without the least feeling of alarm, having an abiding confidence that the Mississippi would continue to be the great highway for the produce of the valley which bears its name, and New Orleans the great depot and point of exportation, if there was free communication with the Gulf of Mexico for vessels of the class required by the yearly increasing necessities of trade; but they must confess that the spectacle which presented itself to them at the bar gave rise to grave apprehensions whether or not it would be possible to retain the trade of New Orleans and maintain its position as the greatest exporting city of the Union unless some measure of relief is speedily granted: nor are the movements going on around calculated to allay these fears. Already rival cities, taking the advantage of our misfortunes, are putting forth their claims to a share of the trade which has heretofore been ours, and which we are constrained to admit, it needs no prophetic eye to discern, must soon seek other channels unless these obstructions are removed; for your committee do not doubt that every facility will be given by our rivals to those frequenting this port and mart, which their own resources and all the outside aid they can bring will command.

In the list of property detained at the bar is comprised one item of nearly 72,000 bales of cotton. Some of these outward-bound ships have been detained for several weeks, and it is hardly to be supposed that parties in want of cotton will again send their orders to New Orleans, if there is the least likelihood of a similar delay in getting it to market; and if this community is not alive to its interests, the now famous cotton mart of New Orleans will speedily become a thing of the past. Again the bills of exchange drawn against the cargoes so detained will, in all probability, mature before the produce arrives, when, by all ordinary calculations, it would have been at hand in time to meet them, and this is another ramification of the evil which may overtake us in the shape of a derangement of our monetary affairs, consequent upon the difficulties which parties may experience in raising funds to retire the same.

Of the value of these cargoes of the inward-bound ships your committee have no data, but they think it may be safely put down at two millions of dollars. Many of these ships are laden with goods destined for the West and western trade, and it requires but a slight effort of the imagination to picture the loss and inconvenience which the owners have suffered by having their goods detained until the proper season for their sale is past. These, again, are not likely to order their supplies to be shipped via New Orleans until they have the assurance that these impediments to the navigation have been permanently removed. In looking at the question from this point of view, we can see that the interest of the consumer, although apparently remote, is actually near and positive. So large an amount of goods being kept out of market, must necessarily enhance the value of those on the spot, and he therefore has to contribute his quota of the loss by the advanced prices which he has to pay for the articles of import which he requires.

One month after the visit of the committee of the chamber of commerce, the state engineer, Mr. L. Hebert, and his first assistant, Mr. L. J. Fremeaux, arrived at the passes to prepare their report to the legislature.

On the 3d of March, they found three vessels aground on Pass à Loutre; one of these, the Mary R. Campbell, drawing 19 feet, had been aground sixty days; another, the Avon, drawing 16½ feet, was on the bar since the previous day; and the third, the Lebanon, drawing 17½ feet, had been there three weeks. The previous day a large ship, the Lancaster, that had been aground forty-eight days, had been at last pulled out of that unpleasant fix. Vessels thus remain on the bar because of the tortuosities of the channel. Each vessel that runs aground causes a diversion and a separation in the current, and consequently the formation of other secondary bars. The strongest tow-boats cannot follow the channel in all its irregularities, and thus it is that they run aground vessels drawing less water than there is in the channel.

Arriving at Southwest Pass on the same day, 3d of March, Engineer Hebert found at anchor, inside of the bars, thirty-five vessels awaiting the possibility of egress. There were also three on the bar and seventeen outside, at anchor awaiting to be towed in. There were then altogether fifty-five vessels detained. Here are some interesting documents concerning thirty of them:

Names of vessels.	Draught.	Days of detention.
	Feet.	
Bullion	16½	8
Fanny Forrester	18	24
J. Montgomery	17½	9
Bessel	18	24
Saint Louis	16½	3
West Point	18	3
Bannockburn	17⅛	10
Potomac	17¼	12
Creole	17½	1
Wm. Lord, jr	18	15
Anau	18¼	7
E. Merson Smith	18½	7
Bamberg	18	22
Mary	18	22
J. Morten	18	25
Huntress	18	15
Levi Woodbury	19	26
Sheridan	18¼	22
Athena	17⅜	10
Barnabas Webb	19¼	29
Lockinvar	17¾	8
E. F. Gabain	19½	39
S. E. Pettigrew	19	26
Ch. Davenport	17¾	1
Victory	18¼	9
Arctic	18½	2
Lady Sale	17¼	1
Ocean Monarch	19¼	5
Wm. Stetson	18¾	1
Czar	17½	3

Between the 28th of February and the 3d of March, at 3 o'clock p. m., a few of the above-named ships were taken to sea, but others had been brought from the city, and as before stated there were on the 3d of March thirty-five vessels. Two of the ships on the bar were much in the way. The Tow-boat Association are busy bringing in and passing out vessels, but they have more than they can do, on account of the immense power they are compelled to use, and the long time they have to give to each ship. With the large number of vessels now detained, and those that are constantly arriving, there would seem to be no end to the work the tow-boats have before them.

One more quotation from an official source will be sufficient to prove that the commerce of our city suffers from the present state of things. The committee of the legislature on commerce and manufactures closes as follows its report of the 3d of March, 1859.

In conclusion, we beg leave to call your attention seriously to the present condition of the bar at the mouth of the Mississippi River, which, at this time, cannot be crossed by a majority of vessels coming in and going out, without great labor, cost, and delay. We further call your attention to the enormous amount of appropriations from the General Government which have been expended in attempts to remove this obstruction, without any benefit whatever. We therefore recommend, and hope your honorable body will take immediate steps to present this state of affairs to Congress, and urge action on the part of the proper authorities.

Independent of the inconveniences enumerated above, some others exist that result from the very position of the mouths of the delta, and their stretching out in the main sea.

Their approach is surrounded by difficulties; no shelter protects the vessels against the wind and waves, and the large number of shoals that are formed in their vicinity renders the services of a pilot indispensable.

During at least eight days per month in the winter season fogs prevail of such intensity as to render ingress or egress impossible. Engineer Hebert mentions this obstacle in his report on the 9th of March. Speaking of his arrival at the passes on the 28th of February, he says:

> Here I encountered such heavy and constant fogs that, although I ran from pass to pass, taking notes of the shipping, steamers, &c., it was only on the 2d and 3d of March that I could make the examination of all the bars.

Moreover the necessity of towing carries with it, as a peremptory consequence, frequent damage, and an extraordinary rapid wear and tear of the vessel. The effect on a ship's hull of the traction of one, and sometimes several tow-boats, pulling her, and making her force her way through a muddy mass, whose surface is generally soft, but which is sometimes hard at a depth of 18 inches, may be easily imagined. We have seen on the 3d of July last, at the Pass à Loutre, four tow-boats hitched to a single vessel, and applying to her four different angular forces. Each of these tow-boats was of at least 400-horse-power; the ship's draught was only 17 feet 8 inches.

Finally, the cost of this so destructive auxiliary force is exorbitant, and while it makes the fortune of the rival companies that carry it on, it burdens our port with a tax exceedingly onerous in our competition with Atlantic ports. It can be estimated at 83 cents per ton for vessels of small tonnage; a ship of a thousand tons pays for towage up and down the river—$1,043, and must bear an additional charge of $150 if compelled to take a second tow-boat to cross the bar.

Official documents estimate the tax levied by towage and pilotage on the commerce of New Orleans at over $2,000,000. And this tax has for its only result to prolong an expedient which compromises our present and future existence.

Let us recapitulate the various charges in an act of accusation which might be made by the commerce of New Orleans against the navigation of the passes. The access to the passes is difficult and dangerous. It is unprotected and exposed to every wind. Pilotage is of imperious necessity. The condition of the passes makes it necessary to employ tow-boats, the use of which is as ruinous to the solidity of the vessel as it is expensive.

The tow-boats themselves are of insufficient number to meet the necessities of navigation; besides, they cannot bring over the bars with anything like regularity ships drawing more than 16 feet.

The vessels thus detained on the bars are exposed to damage, the risk of which augments greatly the rates of insurance.

During all the time of their detention there is a loss to the ship-owners in interest on the ship's capital; in the decrease of an annual circulation of this capital, and in the increase of the crew's wages and consumption of stores. The tardy arrival of his merchandise in the market destroys all the favorable chances of speculation of the shippers of the cargo, the merchandise is exposed to deterioration by the decay, and he runs also the risk of seeing his drafts on foreign markets returned to him protested.

All these causes of complaint fall back upon the merchants of New Orleans, by depreciating our market, and causing our customers to send their orders to other markets, where they are sure to be filled with certainty and promptness.

The committee of the chamber of commerce was, therefore, right when it stated that New Orleans could only preserve her position as the great mart of the Southwest on condition that a free communication

with the Gulf of Mexico be established; *now this free communication does not and cannot exist through the passes.*

The committee adds that this facility of communication must exist for ships of the class claimed by the ever-increasing wants of commerce. This judicious remark leads us back to that which we made on the singular character of the commercial navigation of New Orleans, giving rise to one of the greatest shipping enterprises in the world, that of American cotton to Europe, across the Atlantic, in ships of comparatively small tonnage and slow speed.

We have explained how the state of the passes had imposed these hard conditions upon us. We will state the facts by means of the official figures furnished to us by the statistics of the business of the port.

1. Exportations.

Year.		Vessels.	Exported tonnage.	Tonnage.	Value.
1858–'59	American vessels to foreign ports	834	Exported tonnage	641,392	$101,634,552
	Foreign vessels to foreign ports	336	Do.	167,964	
	Coast trade	1,015	Do.	409,872	
	Total	2,185		1,219,228	
1859–'60	American vessels to foreign ports	958	Exported tonnage	713,588	
	Foreign vessels to foreign ports	334	Do.	180,733	
	Coast trade	943	Do.	354,205	
	Total	2,235		1,248,526	

2. Importations.

Year.		Vessels.	Imported tonnage.	Tonnage.	Value.
1858–'59	American vessels from foreign ports	694	Imported tonnage	492,522	$16,678,093
	Foreign vessels from foreign ports	345	Do.	167,588	
	Coast trade	1,023	Do.	521,972	
	Total	2,062		1,182,082	
1859–'60	American vessels from foreign ports	696	Imported tonnage	458,310	$20,634,393
	Foreign vessels from foreign ports	328	Do.	178,286	
	Coast trade	1,028	Do.	575,433	
	Total	2,052		1,212,029	

Total numer of vessels circulating across the passes has therefore been 4,247 in 1858–'59, and 4,287 in 1859–'60, both for exportation and importation, and the tonnage has been 2,401,310 tons in 1858–'59 and 2,460,555 in 1859–'60.

The comparison of these two years gives us an average of 565 tons per vessel for the preceding, and 574 tons per vessel for the current, year.

But if we examine especially the exportations to foreign ports, we find in 1859 1,170 vessels exporting 809,356 tons, which gives us an average of 692 tons per vessel. In 1850 there were 1,292 vessels exporting 894,321 tons, making again an average tonnage to foreign ports of 692 tons.

It will be seen that this tonnage, so small when compared to that of Atlantic ports having vessels of 1,200, 1,500, and 1,800 tons, is required by the nature of the outlets of the Mississippi. In fact it can be admitted as an average that a vessel of 600 tons draws 14½ feet of water;

one of 800 tons draws 16 feet of water; one of 1,000 tons draws 18½ feet of water; one of 1,200 tons draws 20 feet of water; one of 1,500 tons draws 21 feet of water. Can such a state of things continue at a time when it is demonstrated that the greatest profits are earned by the largest ships?

It is evident that, due allowance made for proportion, large vessels cost less to build than small ones; they take less materials, secure a greater economy in the general expenses, and are safer. All possible advantages will then be found in substituting large vessels for small ones wherever the natural conditions of navigation will permit this change. As for ourselves, until we shall have created an outlet to the Mississippi, with a regular depth of 22 to 24 feet, we will find it impossible to realize this progress.

Ships of a large tonnage may, it is true, run the same disadvantageous chances as smaller ones, such as returning in ballast; but an examination of the preceding statistics shows that the difference between the tonnage of exportation and importation is small, and that the difference will diminish as soon as the direct trade of large ships between our port and Europe will compel those ships to bring to us directly, in order to make their return cargoes, those articles of importation which we are now receiving indirectly and by the way of the North.

If the value of our importations be compared to that of our exportations, the following results will be found:

In 1858–'59, importations, $16,678,092; exportations, $101,634,952; difference, $84,956,860. In 1859–'60, importations, $20,634,393; exportations, $108,393,567; difference, $87,759,174. Now, in 1858–'59, we received, in specie, $15,627,017; and in 1859–'60 we received, in specie, $8,444,857. There is, therefore, a balance in our favor in 1858–'59 of $60,329,844, and in 1859–'60 of $79,314,317.

This balance is refunded to us from abroad in the shape of merchandise exported to the North, which makes good use of it in the settling of our accounts with the interior, thereby making double profits; first, as brokers between Europe and ourselves; and secondly, between us and our customers of the interior, without counting their profits as shipowners and freight-carriers.

From the day that a free access to our port will permit a large direct trade with Europe, this balance will in great part come to us directly, and it is from our wharves that the distribution of these goods will be made; the mean value of the ton of imported goods being $14.11 for the year 1858–'59, and $17.02 for 1859–'60, while the value of exported goods per ton is $83.36 for 1858–'59, and $86.82 for 1859–'60. There will be a business of importation equal to about that of exportation, but of fourfold tonnage.

Then it is that, to furnish return freights to this increased number of arrivals, we will have to struggle, in our turn, to get back a portion of those agricultural products of the West which the Northeast has attracted to its ports by its railways; but then we will have conquered new advantages, and, being able to offer to those products an easy and regular outlet, at direct transportation to Europe, and ships of a large tonnage, we will find ourselves engaged in competition altogether advantageous to us. The railroad interest of the North already feels this. To sustain their roads it has been found necessary to increase the tariff, and under this increase of freight we find the following results in the comparative transportation of a cargo of 3,000 barrels of flour shipped from Cincinnati to Liverpool by the way of New York and by the way of New Orleans:

From Cincinnati to New York, $1.75 per barrel.....	$2 25
From New York to Liverpool, 50 cents per barrel.....	
From Cincinnati to New Orleans, 50 cents per barrel.....	$1 46
From New Orleans to Liverpool, 96 cents per barrel.....	

Difference in favor of New Orleans, 79 cents per barrel.

This difference will be still greater when our trade will be direct and carried on in large ships, and independent of the passage over the bars and the attending charges.

CANAL BETWEEN THE MISSISSIPPI AND THE GULF OF MEXICO.

Section 1.—General conditions.

The Mississippi has no outlet adequate for its commerce, and it is important that one should be created without delay. These are the two propositions we have demonstrated. We have now to describe this artificial outlet, and to study it with the attention which its importance deserves.

Let us specify, first, the conditions that it must satisfy.

1st. It must free navigation of all the difficulties which surround the mouths of the river; it must, therefore, be a certain distance above the passes.

2d. It must not lengthen the term of navigation in the Gulf of Mexico, a sea so dangerous and exposed to gales. It must, therefore, admit the vessels in the river as near as possible to its mouths.

3d. It must not, moreover, be too far from the natural mouths of the river, in order not to create too great a difference of level between its point of junction with the river and its junction with the sea.

4th. It must be placed at a point on the river where there exists no battures and no fears of battures forming subsequently.

5th. It must be on the shortest line between the river and the sea, on condition, however, that this advantage shall not be compensated by a considerable increase in the expense.

6th. It must present, at its opening on the sea, natural shelters to protect the approach of vessels.

7th. It must, besides, offer a direction little inclined with that of the wind prevailing during the greater part of the year.

8th. It must open on the sea at a point where no accretion and no decrease in the present depth of water are to be feared.

9th. It must offer to vessels secure anchorage, so they may be in safety outside the canal.

10th. It must free vessels from all necessity of pilotage, and, consequently, avoid their circulation among the islands, keys, and reefs, which in the passes require the services of a pilot.

11th. It must also do away with the necessity of towing, at least as far as the river, where the wind often permits vessels to ascend directly from the English Town as far as New Orleans.

12th. It must have a constant depth of 22 to 24 feet of water, in order to permit the access to the river of ships of the greatest tonnage.

13th. It must be forever secure, by its conditions of existence, from those perturbations which render the passes impracticable to the navigation of large vessels: that is to say, from the action of the sea, from accretions from the river, from sand-banks formed by any agency.

It will be seen from the description we are about giving of the pro-

posed canal, and from its topographical conditions, that it will satisfy, strictly and precisely, all these exigencies.

Section 2.—Topographical and hydrographical description.

When, going down the Mississippi, we arrive at Fort Saint Philip, we see the majestic course of the river developing itself on a length of eighteen miles, as far as the head of the passes, without sinuosities or turns. The mass of water moves always in the same direction, without any sensible inflections in its banks. But as the current came from the southwest, and has inflected to the southeast from the bend of the forts, the result is that its greatest swiftness and depth are near the left bank, while the water is smoother and deposits its accretions near the right bank. From three to eight miles below the fort repeated soundings have given us depths of 24, 25, 26, and 28 feet, at a distance of 20 and 25 feet from the bank; 20 feet farther the lead sinks to 62, 71, and 87 feet.

If we stop seven miles below Fort Saint Philip, that is to say, precisely on the 90° 31′ longitude west, we are at a mean distance of twenty-two miles from the passes, which, from the declivity assigned to the river, to wit, 3½ inches per mile, would represent a difference of 7½ feet in the level from that point to the surface of the Gulf. Levelings made by us between this point and the Gulf show that it is only 3 feet higher than the Gulf at mean tide. It is therefore possible to shorten the navigation of the river twenty-seven miles at this point, having to make up a difference of only 3½ feet declivity at mean water, and 7 feet at the highest water-mark.

This point being chosen at the head of the canal fulfills completely the first three conditions mentioned above. Let us see if it can satisfy, equally, the others.

If from the top of one of the few huts to be found on that bank, upon which, from Fort Saint Philip to the sea, there exists no important establishment except the salt-works opposite the Jump—if from this observatory we turn our back upon the river and we look around us, we will see, extending indefinitely to the horizon, a scene of extreme monotony. The left bank of the river from the fort to the head of the passes is a mere neck of land hemmed in between the waters of the Mississippi and those of the sea. Its width, except at few points, does not exceed a mile, and at other points it is narrowed down to a few arpents. An additional mile may be considered as a dependency of the mainland, although cut up in every direction by canals, lagoons, and bayous of an average depth of two or three feet during tide time, and which are transformed into mud or sand-banks during low tides. Beyond this is a series of small bays from three to eight feet deep, and studded with a quantity of islets, between which there opens deeper passes or deposits accretions upon which numerous oyster-banks are formed.

On the right, on the east line, one of these islets, Bird's Island, of more importance than the others from its length, runs from north to south a distance of four miles; on its eastern point a watch-tower has been built, which commands a view of the sea. Going up from east to north, a long sandy beach, known as Sand Island, forms the limit of these low lands.

In the direction of the northeast, the last of these islands, called the Pavillon Island, fronts an island situated six miles off at sea, and to which we will have occasion to refer; it is Breton Island.

To the left of this islet another neck of land, called the hard batture,

runs out to meet an island, two and one-half miles long, Grandes Coquilles Island, which is in the due north point, and is only separated by a channel from the smaller Coquille Islands connected in low water with the mainland of Fort Saint Philip.

It is therefore in this semi-circle, the center of which we have placed on the river seven miles below Fort Saint Philip, and the circumference of which runs from the southeast to the northwest, that a real archipelago of islands and of lands cut up by lagoons and bays, but uniform in their aspect and their nature, is comprised, evidently created by sea-deposits, but with materials furnished by the Mississippi; they reveal to a geological study the character of the marly accretions to be found in all deposits of the river. The bottom of the bays and lagoons, covered at certain points by a soft mire which has not yet hardened, is everywhere else perfectly hard, and the purest clay sticks to the lead. All these lands, scarcely out of the sea and which it covers in its usual tides and destroys or tears up in its angry moods, only offers to the eye the monotonous vegetation of sea-weeds, graminivorous plants, and mangroves.

The radius of this semi-circle, from its center on the river to Pavillon Island, is of six miles. It is on this radius that the projected canal runs. It cuts first the two miles of solid land, crosses the large bay in that part of it where the water is lowest, crosses a prairie one mile wide, and pursuing its course through the lagoons and mud-banks it reaches Pavillon Island, having its outlet in the pass of Breton Island.

It may appear singular that we should have chosen this point of the coast when we have already stated that three miles below the salt-works the neck of land has only a width of a few arpents between the river and the sea: but a simple reflection will justify this apparent contradiction. The object in view is not simply to cut the canal to the sea, which may be done by cutting through a length of 1,000 feet, but it is to open it on the deep sea, that is, at a point where large ships drawing 22 to 24 feet can have easy access. Outside of the mainland there is a border of batture, which in some places projects twelve or fifteen miles, and beyond this batture, whose conventional line is at a depth of 12 feet, the declivity is sometimes so small that a long distance must be made before the necessary depth of water can be met.

The distance of six miles which we have found for the line of the canal is the shortest between the river and the deep sea that can be formed from the forts to the passes, and it is even necessary, in front of Pavillon Island, to dig and continue the canal through a batture for a distance of 3,000 feet to arrive at the required depth.

Another circumstance, altogether exceptional, militates in favor of this side. Hydraulic works or works of embankments made in 2 or 3 feet of water may be considered as made on land; while those made in 8 or 12 feet of water are extremely difficult and expensive. Now, on the line indicated, about three-fourths of the passage are made on the land, and for the other fourth, the average depth of the sea does not exceed 2 feet. This plan combines, then, the advantages of the mimimum of distance and the mimimum of cost.

Let us examine the access to the canal from the seaside:

We have already said that by following the northeast line, which is that of the canal, there would be found on the main sea, and at a distance of about six miles from Pavillon Island, an island known as Breton Island. This island, which had formerly a length of six miles, and was then occupied by a colonist living with his family in the midst

of the vast Gulf, was cut off by a sea-storm that took off from it an islet of half a mile in length, on which a watch-tower has been raised, which would be replaced by a light-house. As cut up as it is, this island, with the batture that extends on its right and left, has a length of ten miles, running almost straightly from east to west, and forming consequently an excellent shelter for vessels against north and northeast winds.

The coast of the river above the fort, and the large peninsula of Lake Borgne, afford protection against the northwest winds.

The coast of the river below the fort shields the canal from southeast winds.

Finally, the south winds are intercepted by the large eastern opening of the delta.

The head of the canal is therefore exposed to the east wind alone, and it is precisely this wind which will bring the vessels from the main sea; it can only facilitate their arrival and bring them in a direct line to the port.

The direction of the canal being northeast, it will be seen that the ships with an east wind will sail directly for the canal with the wind over the quarter, a very favorable direction, indeed, both for facility of maneuver and speed. The pier that terminates the canal opens in a semicircle, to afford ample and convenient room.

The existence of natural shelters being thus established, can we depend equally on the depth of water in the channel formed between Pavillon and Breton Islands? It is principally that point which we have investigated.

Besides numerous soundings in all that region, represented graphically, we have inserted in the plans the series of soundings from the head of the canal to the watch-tower on Breton Island. This line consists of the following points: 26 feet, 36, 35, 36, 39, 34, 19, 14, and 12. These last three soundings are in the vicinity of the batture of Breton Island, the former occupying a breadth of four miles. We have also, (although it was one mile north of the canal, and consequently of no great importance) determined a second line from the most advanced point of the reef of Breton Island and of the island of the Hard Batture, where that pass is narrowest, and we have formed the following figures: 21, 36, 32, 28, 32, 32, 36, 10. It will be seen that ships will have certain access to the canal with fully sufficient water.

But with the continual changes made by the Gulf in that region, is there no fear of the future creation of obstacles, such as those that obstruct the passes of the river? We will reply to this query first by arguments, then by facts. It is very true that the tendency of the sea is evidently to fill up all its eastern portion along the river, and to fill up gradually all the lagoons so as to form them into main-land. If it destroys accidentally, it creates constantly, and for this very reason certain passes must necessarily remain where the swiftness, and consequently the depth, will increase instead of diminishing. Such is the case with the two passes that exist west and east of Breton Island, that is, on one side between that island and the promontory caused by the canal, and on the other between that same island and the great batture which begins at Grand Gosier Island and serves without interruption as a basis to the archipelago of the Chandeleur Islands. It is by these two passes alone that communication can be obtained between the Gulf and the Mississippi sound within one degree of longitude.

So much for arguments. As to the facts, the comparison of the soundings made in 1827 and consigned on the fine map of the Gulf of

Mexico, by Mr. Edmund Blunt, with the soundings made by us, prove that the depth of water has increased in the west pass of Breton Island since that time. These first soundings give 36 feet only on one point of the coast; everywhere else they give 18 and 24 feet.

Among all the advantages we have pointed out in this predestined locality, there is one that we have mentioned too concisely, and which plays too important a part that we should not dwell upon it now. It is the nature of the sea-bottom and of the soil of the island which the canal will have to cross. Reiterated geological soundings that have uniformly given us 14 feet of sand clay enabled us to verify that it is impossible to find a species of clay more firm, more homogeneous, and more resisting. The anchor bites freely, and once imbedded in it, runs no risk of dragging. The vessels are, therefore, certain of being able to lie at anchor outside of the canal as long as may be desired, under shelter of either Breton Island or Bird Island.

The precious quality of this soil will be again evident when we take up the question of construction.

These grand conditions once determined, their consequences may be drawn naturally. The vessels arrive from the high sea into a sort of gulf, opening due east, and circumscribed to the south by the northern bank of Pass à Loutre, to the west by the river and Bird Island, and to the north by Breton and Grand Gosier Islands. *In this gulf cannot be found a rock, a reef, or an islet. Its depths vary in the mean line 90 to 36 feet. The light-house on Breton Island and that on the pier of the canal will point out the entrance to the latter. There will be, therefore, no necessity for pilots; no port will ever have an easier and more direct access.*

It is useless to add that, until their entrance in the canal, the ships will have no need of tows. Once in the canal, the towing will be performed by means of locomotives running on a railway built on the top of one of the levees. It is, therefore, only after their arrival in the river that the ships will, if the wind is not favorable, employ tow-boats to ascend the river.

Of all the conditions we have set forth as necessary to an artificial opening of the Mississippi, two yet remain to be fulfilled—the creating of a depth of 22 to 24 feet, and the assurance that this depth cannot be altered or reduced by either the sea or the river.

These two conditions do not depend on topographical or hydrographical data, but on the construction of the canal itself.

Section 3.—Draught and construction.

It may be asserted with confidence that no work more important in its consequences has ever presented fewer difficulties of execution, and involved less cost, than the canal of which we have demonstrated the necessity. Consequently, its description need not be long or complicated.

First, the difference in declivity between its two extremes is of 4½ feet; the difference of level between the waters of the river and those of the sea is only of 3 feet, in ordinary conditions. When the river rises, the sea may be below the level of the river as much as six feet.

The slope of 4½ feet on the horizontal line is almost entirely level from a distance of 3,000 feet from the river; it is therefore reclaimed by a single lock, and outside of this the canal may be considered as being perfectly level. But for the necessity of protecting the talus against the surf of the sea, there would be no necessity for another sluice at the other end.

It is an entirely level country, with no obstacles to overcome, no trenches to be made, no rivers to be crossed, no excavations to be made. Its alimentation presents no difficulties; no fears need be entertained of filtrations or leaks occurring, save those that might affect the solidity of the work. It is in truth a gigantic ditch, unsheltered, perfectly rectilinear, and of complete uniformity on a length of six miles. It will be a great undertaking only by its dimensions and its results.

To determine these dimensions we must remember the object of the canal, which is to open a large road to sea-navigation, to ships and steamers of the greatest size; to continue in some way the draught of the deep sea and of the river without sensible interruption.

But few examples of analogous works can be consulted by way of comparison, and among them only one has been executed, another is now in course of execution; the two others are as yet but projects.

Canals.	Length.	Width at water-line.	Width of bottom.	Depth.	Number of sluices.	Width of sluices.	Length of the locks.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Caledonia Canal	21	110	50	20	24	40	172
Canal of the Isthmus of Suez	90	300 to 195	208 to 103	23	2	63	300
Canal of Nicaragua, (Garella's project.)	.....	134	.....	21	.....	.....	.....
Canal of Nicaragua, (Napoleon's project.)	82	147	.....	23	32	47	210
Canal from Mississippi River to the Gulf.	6	100	30	24	3	80	400

We owe some explanations on the remarkable differences presented by the dimensions proposed by us compared with the others in the above table.

The prevailing thought in our mind has been to leave free scope to the creations of the future, and, while remaining within the limits of what is possible and reasonable, to give a wide margin to the already manifest tendency to constructing very large ships. Therefore for all the dimensions claimed for their admission, we have gone beyond the given corresponding figures for the other canals: 24 feet draught at low water; 400 feet locks; 80 feet of openings to the sluices. We have taken as a basis for these speculations on the future, the dimensions of the largest steamer ever constructed, except the Great Eastern. The Adriatic has a length of 345 feet and a width of 75 feet outside the wheels. She draws 23 feet of water and measures 4,144 tons.

The Great Republic, the largest sailing-vessel existing, draws 23 feet and has a length of 302 feet and a breadth of 48 feet.

Some time will elapse before New Orleans can see vessels requiring such outlets arrive at her wharves; but, at all events, if such should come, she will be able to admit them. However, there is a figure for which we have remained far below the large sea-canals; it is that of the width of the canal. It is only 100 feet; that is 10 feet less than the narrowest of these canals, the Caledonian Canal.

It must be known, first, that the Caledonian Canal, however small its section, gives access to the largest merchant-ships and to steamships and propellers of a large tonnage. Moreover, in its length, which is of fifty-nine miles, comprising thirty-eight miles in Lakes Lochy, Oich, and

Ness, there is much circulation in opposite directions. It is, then, necessary that two large ships should be able to pass each other. The same condition exists in all other canals mentioned.

Such is not the case with our Mississippi Canal. Circulation there can only take place in one direction according to whether the towing locomotives are going from the river to the sea or from the sea to the river. By this combination there is a gain of one sluice, and for a long time to come circulation will not be rapid enough to require other means. Thus a convoy of ships arrives from sea and enters the neck formed by the two piers. The locomotive takes hold of it and tows it to the nearest or seaward sluice, which opens, and the convoy enters the locks. The gates of the seaward sluice close; those of the head sluice open; the level is formed and the convoy enters the river. Then the vessels, awaiting at the wharf on the river, avail themselves of this leveling to enter in their turn in the canal, and they are towed to sea.

The result from this system of working, that the width of 100 feet in our canal is equivalent to a width of 200 feet in canals where ships meet and cross each other. Let us add here, moreover, that toward the center of the canal will be found a basin, 600 feet long and 200 feet wide, to be used as a wet-dock.

It will be easily understood that this system would have been impossible had the canal had a greater length. The time necessary for the towage would have occasioned too much to ships awaiting ingress or egress.

According to the table already quoted the movements of import and export nearly balance; there was in 1858–'59 2,062 arrivals and 2,185 departures, and in 1859–'60, 2,052 arrivals and 2,235 departures.

In the month of November, when this movement was most animated, 267 vessels arrived, to wit, 152 ships, 40 barks, 18 brigs, 29 schooners and 28 steamships. This gives an average of 9 per day and as many departures. By doubling these figures the result would only be 18 ships in each direction, or a daily circulation of 36 ships, which, by taking the average of 574 tons per ship, would give 20,664 tons.

The time necessary to cross the two sluices being about fifty minutes, it will take the locomotive one hour and ten minutes to take the vessels and run the six miles. This moderate speed has for object not to injure the embankment; each trip will then occupy two hours.

At the rate of twelve trips per day it is three ships, or little over 1,700 tons, per trip. Nothing can be more practicable than these calculations, although they correspond to a circulation double of that which takes place at the time of the year when the commercial movement attains its maximum.

If we follow the plan of the canal in its short and simple line from the river to the sea, we will find at its head, on the Mississippi, a light-house placed on the upper embankment; the object of this light-house is to point out to ships coming down where they must stop. There is to be formed from this embankment, running to a length of half a mile, a wharf along which the ships, and tows they may need, will line themselves. Behind the wharf and at the head sluice is placed the house of the keeper of the canal and the custom-house office; opposite, on the other side of the lock, is the building used as the locomotive-depot and containing a machine-shop and a store-house for the urgent repairs and supplying of the vessels.

The head sluice, of a width of 80 feet, gives entrance into a lock 400 feet in length, closed by the middle sluice; the latter gives passage

into a channel formed by levees in embankments. From this point the shape of the canal is uniform as far as the sluice at the sea head.

This profile presents a section 100 feet wide at the low-water mark, 24 feet deep and 30 feet wide at the bottom. The slope of the banks or talus is therefore, on each side, of 35 feet base for 24 feet height, that is about 1½ to 1, corresponding to an angle of 32°. This easy slope is more than sufficient, with the compact nature of the soil, for the preservation of the banks.

On the right and left of the water-line, a berme 15 feet wide is formed; it serves to receive the falling in that might occur in the upper levee, and also to increase the strength of this levee and consolidate its base.

On each side of this base rises the levee formed with the earth from the canal. It is 10 feet high, and consequently meets the upper level of the lateral walls, the brick-work of which is 34 feet above the bottom of the canal. The width of the levee at its top is 15 feet, and for its greater solidity it will have 60 feet at its base; it is a slope of 40, corresponding to an angle of 20°.

On the lower levee (in relation to the river) the railroad for the towage of the ships is built. Two turning-tables, situated at the two extremities of the line, permit the direction of the locomotive to be changed.

From the middle sluice the canal runs a distance of 13,880 feet in mainland on a level. It is a prairie, cut in the last mile by a few unimportant lagoons. It crosses then the large bay on a width of 5,600 feet. It is during this passage that it spreads out in the basin that we have mentioned. This basin will be used as a wet-dock for the dredging-machines for the boats employed in the service of the canal, and for the vessels which, for some reason, would need to stop on their way. Coming out of the bay the canal runs 4,000 feet through a prairie; it runs again into a series of lagoons of 3,000 feet, gains land once more for a distance of 2,600 feet, and finally crosses a last bay of 1,900 feet to arrive at Pavillon Island, which it cuts upon a length of 400 feet.

It is on the outer shore of this island—that which faces the sea—that the pile of masonry intended to contain the seaward sluice is constructed. There, also, will be the house of the keeper of the sluice.

The two arms of the lateral embankments of the sluice on the sea-side, from the head of the double pier, which, starting from this island in the direction of the axis of the canal for a distance of 3,000 feet, where the depth of 24 feet at low water is found. These two piers, between which it will be necessary to excavate the batture, are the only works of art in the canal. And this work can only be looked upon as a feeble specimen of analogous conceived and executed by modern science. Thus the dike of Cherbourg has 11,300 feet of length, in depths of 44 feet of water.

The pier of Plymouth has over 1,000 feet in 34 feet of water. The dike in the Bay of Delaware has 3,600 feet in a depth of 42 feet; that destined to form the port of Peluse, for the entrance to the Suez Canal, will have 18,000 feet of development until it attains a depth of 24 feet.

The south pier on which the railroad will be built, will terminate at its end by a large mole of 100 feet diameter, in the center of which will be placed a light-house with lenticular apparatus.

The description gives a complete idea of the canal. We have now to show how the depth of 24 feet which we have given it cannot be subject to any change, either in increase or decrease.

The increase in the depth would have the inconvenience of under-

mining the foundations of the masonry or the base of the embankments and produce a caving in. This danger is not to be feared on the river side. It will be seen that its waters scarcely penetrate in the canal; it could, therefore, only exist from the sea side; but, when the sea threatens, the outer lock is immediately closed and the whole channel is as smooth as a pond. As to the bottom of the lengthening of 3,000 feet situated between the two piers, its depth and its shelter are such that the sea will remain smooth there at all seasons.

There remains the otherwise dreadful danger of a reduction in the depth; that is, a reduction in the 24 feet depth originally given to the canal. Then, again, the cause would exist either in a bar formed at the entrance of the canal in the sea, or in alluvions deposited by the waters of the river. As regards the sea we have seen that the canal opens on the west pass of Breton Island, at a point where the waters of the Gulf becoming compressed increase in speed, and rather tend to deepen their bed instead of filling it. This circumstance is sufficient to prove that the sea, instead of forming a bar at the entrance of the canal, would, if a foreign agency created one there, take it crosswise and sweep it off.

Can we feel as secure on the river side? The waters as they enter the lock bring at each sluice-full a volume of 14,400 cubic feet, representing about 85 cubic feet of earth. It is apparent that, with twelve sluice-fulls per day, the progressive filling up of the canal might be feared, but a very simple disposition, sanctioned by experience, enables us to avoid this inconvenience. A gate made in the center of the laterals forms the opening to a vault which crosses the thickness of this masonwork and opens on a discharging canal. The sill of this door or gate is on a level with the water line of the canal, and it is closed when the waters of the river enter the lock. So soon as the level is established between the lock and the river, and when the ships have passed from the river into the lock, instead of opening the gates of the middle sluice, this lateral gate is opened; the river water, which, from its lesser density, has in great part floated upon the salt water, runs out by this outlet, and the gates of the middle sluice are only opened when the level has come down to the water line. By this means the waters of the river only penetrate into the channel in very trifling quantity.

Besides, if any accretion were formed in the channel or in the locks on the river side, it would be sufficient to take advantage of the season when the river being at low-water mark and the sea at high water, (the level of the latter is a few feet higher than the former,) to use this difference of level for sweeping off of all deposits that might have accrued.

As to the accretions we might suppose would exist in the river at the entrance of the head sluice, the study of the river's course has proved that, from its natural regimen, they are not to be feared, the accretions forming themselves on the opposite bank.

Thus, all the objections that might be raised against the opening of an artificial outlet to the Mississippi have been met. The circumstances in which we execute it must free us forever of all fear that those two great obstructors of the passes, the Mississippi and the sea, could inspire.

EXPENSES AND REVENUES OF THE CANAL.

The estimation of the cost of the canal and its revenues is subdivided in several chapters, which may be recapitulated under the following titles:

1. Value and supply of the materials.
2. Order and direction of the works.
3. Value of the works.
4. Means of execution.
5. Revenues of the canal.

1.—*Value and supply of the materials.*

The necessary materials are wood, granite, iron, cast iron, brick, lime, sand, pozzolana, shells, and fuel.

Examining, according to the rules of engineering, the resources presented by the locality, we must be surprised to find so many assembled on this spot. Excepting granite and iron, we find all the other materials on the spot and in a very limited space.

WOOD.—It is well known that the coasts of the Mississippi are one of the greatest markets for pine and cypress lumber. For more than half a century France and England have been receiving cargoes of lumber shipped from Ship Island and Pensacola. Now these two points are only distant, one sixty miles and the other one hundred and twenty miles from the canal. All the pine and cypress needed will, therefore, reach us by a direct line of navigation.

The pine logs for the piles will come at $5 per thousand feet, delivered; the same sold as worked timber will not cost over $10 per thousand feet; two-inch pine boards will be worth $11.

The cypress timber will come at $25; the cross-ties for the railroad will cost 75 cents apiece.

Oak timber brought from Saint Louis, by the way of the river, may be calculated at $35.

IRON AND CASTINGS.—Iron will only be used for smith's work, and to strengthen joints. It is an important matter in our calculations. It may be valued at 7 cents per pound, and at 4 cents—all delivered. The cast iron will be used principally for the railroad, and will cost $35 per thousand pounds.

GRANITE.—The granite will be shipped from Boston, bored to order; it will cost $1.25 per cubic foot.

BRICKS.—No better earth for the manufacture of bricks can be found than that coming from the excavations of the canal itself. They will be made on the spot at a cost of $7 per thousand.

LIME.—We have mentioned an island near Fort Saint Philip, called "L'île à Coquilles," (Shell Island.) It is a large mound furnishing all the material for the manufacture on a large scale. This lime can be made at a cost of 75 cents per barrel.

POZZOLANA.—The marly clay of which we have spoken will furnish the artificial pozzolana intended to change the common shell-lime into hydraulic lime. It may be valued at 50 cents.

SANDS, SHELLS, CLAY.—These materials, which are to be found on the spot, have no other value than that of the necessary labor to gather them. We will set them at 10 cents per barrel.

FUEL.—The only cost of fuel will be the labor and transportation from the banks of the river to the spot where it will be used. The inexhaustible quantity of drift-wood on the river furnish logs, which the inhabitants on that coast have split, and sell as cord-wood to the steamboats. This wood may be valued at $2 per cord.

Order and direction of the work.

In order that the following estimate may be understood without an examination of the detailed plan of the canal, it is proper to indicate

how the works will be organized and how conducted, so as to be completed in the space of two years.

The lines of axis and outlines being marked on the ground, a gang of ditchers will dig up all the cube of earth on the bank of the river that exceeds the level of its waters. Then, two dredging machines of 35 horse-power, and capable of excavating the depth of 12 feet, will commence at the bank of the river; they will clear all that space to be occupied by the lock and its sluices, leaving to the sides of this lump the necessary talus to prevent the caving in.

This lump once cleared, one of the machines will dig on the axis of the canal a passage of 50 feet, and, after following the passage for a distance of 200 feet, it will place itself crosswise and will begin the excavation of the channel on one of its banks. The other machine, passing by the same road, will turn in the opposite direction from the first, and will commence with the channel on its other bank. They will continue this operation indefinitely. Behind them a dredge-boat of 50 horse-power will proceed to the final excavation, to the total depth of 24 feet. During this time three pile-driving boats will begin driving the necessary piles for the formation of a dike in the river, intended to inclose in front the space of the lock. Another of these boats will drive the piles of the dike at the end of the space where the dredge-boats will have entered the channel.

When the dikes will have been completed, a draining-machine of 30 horse-power will empty completely the space and maintain it perfectly dry. Then will begin the driving of the piles for the construction of the first floor. A trellis-work will be placed on these piles, and the hollows filled with beton. The trellis will be covered with a floor, on both sides of which will begin the lateral walls of the lock. A second trellis-work, with a band under each counterfort, will extend the whole length of the lock between the lateral walls, and will receive the double flooring of frame.

The mason-work of the lateral walls will be 34 feet high, 12 feet thick at the top and 24 at the base. It will be buttressed on the land side by 22 counterforts of same thickness. The outside facings of the lateral walls will be of granite, the interior masonry of bricks laid in hydraulic cement.

While, on the river-side, the excavating of the channel and the construction of the lock will be carried on, the same operations will be performed on the sea-side.

A dredge of 50 horse-power, with capacity to excavate 24 feet, will begin the excavation from the deep-sea side, going toward Pavillon Island, on a line with the axis of the canal. When it will have excavated the space to be occupied by the mole and by the two heads of the pier, two pile-driving boats will come and drive the piles, by means of which will be constructed two dikes, one for the head of the north pier, the other for the head of the south pier with the mole attached.

When it will have reached a 12-foot depth, the 50-foot horse-power dredge will be replaced by another of 35 horse-power, which will continue the channel between the two piers of the necessary width not only for the channel, but also for the foundations of the piers; it will work this way as far as Pavillion Island. Then begins the same kind of work as at the river-head, to wit, excavating of the lump for the sea-side sluice, lengthening of a passage 50 feet, to introduce the dredge-boat in the line of the channel, the excavation of which will be done by this boat until it will have met the two other boats coming from the river end.

Meanwhile, two dikes, one on the sea, the other in the 50-foot passage, will inclose the lump intended to receive the sluice on the sea-side.

When it will have completely inclosed, the draining-machine will drain it, and the pile-driving, trellis-frame, beton filling, laying of the flooring and frame-work, will be constructed in the manner already explained. The masonry will be made in the same style and proportions, with granite facings, like all the other exterior facings of the constructions of the canal.

The piers and mole will have been constructed in the mean time, and these works are carried on simultaneously.

The mole is a pile of brick-work (it could be constructed of beton) forming an annular cylindrical mass, whose interior hollow is of 72 feet, and the thickness of the ring of 12 feet. It is coated outwardly with granite on all its circumference, and its upper platform is also of granite.

Finally, the piers can be undertaken independent of the other works. The first operation will be to sink in the channel comprised between their two sides, and in all the space they occupy, a flooring intended to level the bed excavated by the dredges, and to connect the two piers by a common base.

This flooring, the bottom of which is full and the upper part formed by a trellis filled with beton, will be sunk to the bottom by panels of 25 feet; once levelled by means of concrete blocks of beton having 4 feet height, 24 feet in the direction perpendicular to the axis, and 10 feet parallel thereto, will be sunk at 50 feet distance on the right and left of the axis of the canal. These blocks are hollow, and their sides are one foot thick; they may, if necessary, and for the better strengthening, be filled with earth. The face of the canal is slightly inclined. The two upper layers will only have 22 feet, offering a decrease of 2 feet on the sea-side; this graded deduction will extend to the water-line, where the length of the blocks will only be of 18 feet. The 10 feet of pier from the water-line to the level of the lateral walls of the sluice will be constructed of bricks.

In short, it will be seen that all the different points of the works may be begun simultaneously, and there is no impediment to the forming of six or seven gangs, except the assembling of so many workmen on the same spot, the difficulty of superintending such a large number, the difficulty of supplying materials, the incumbrance caused by the arrivals and other obstacles that will be understood by practical men. It is well understood that the order of the works may be modified according to circumstances.

We will pass now to the estimate of the cost of each part of this great enterprise.

Value of the works.

SECTION 1.—Head-sluices and locks on the river:

Dikes	$2,700
Excavating and draining	29,917
Pile-driving, trellining, and filling with beton	12,324
General flooring and frame-work	13,810
Masonry, bricks, and granite	184,170
Puddling, and levelling the rubbish	8,700
Sluice-gates and accessories	8,000
	$259,621

SECTION 2.—Channel and embankments:

We must set forth here the data which have served us as a basis for the estimates at this important part of the work. After a long discussion of the analogous works performed in the ports of Toulon and Valence, on the Seine, and on the bars of the Nile, the engineers of the Suez Canal have adopted machines that not only perform the excavating, but also, by means of revolving carriers, transfer the rubbish on the bank. These machines, of 35 horse-power, working 250 days per year, can excavate 375,000 cubic yards, at an average cost of 20 cents. The 50 horse-power engines will work at the rate of 30 cents per cubic yard. The work of the opening of the channel is to be done, as stated, in prairie land, for a distance of 21,580 feet, and in lagoons for 10,500 feet, on an average depth of 2 feet. During all this passage through the lagoons it is necessary to form, on each side of the canal, a casing made of piles and boards, rising to the height of 3 feet above high-water mark, and preventing the sea from washing off the rubbish that is to form the banquettes and levee. This work is necessary in order to allow the levee to settle and consolidate.

The digging through prairie land will cost	300,140	
Through lagoons, comprising the basin	121,506	
The wood-work in the lagoons	16,848	
The making of the levees, both in prairies and lagoons	182,004	
		$620,588

We cannot pass silently the result of the calculation of filling, as compared with the excavating. We had indicated, as a basis perfectly sufficient for the solidity of the levee, a length of 600 feet; that is, 22½ feet of base on each side, for a height of 10 feet; but the disposable rubbish will enable us, while leaving the slope on the canal side, to extend the base on the outer side as far as 120 feet from the banquette, which will give a nearly horizontal talus, and relieves us of all fears of the action of the sea, even in the hurricanes.

SECTION 3.—Seaside sluice, (excavating already comprised in the preceding chapter:)

Dikes and drainage	$3,164	
Piles, trellis, and beton work	7,008	
General flooring and frame-work	5,153	
Masonry, bricks, and granite	55,302	
Puddling, and leveling the rubbish	2,040	
Sluice-gates and accessories	4,000	
		76,667

SECTION 4.—Piers and mole:

Piers.—Excavating and leveling rubbish	$107,584	
Inferior flooring and concrete filling	151,124	
Temporary wood-work for construction of piers	45,000	
Masonry, concrete works, bricks, granite heads of 200 feet, both inside and outside, say 800 feet	646,197	
Mole.—Masonry and filling, granite facings	50,188	
		1,000,093

SECTION 5.—Accessory works and appendages :		
Temporary building for the workmen, diving-bell, pumps, and fresh-water ditch, warehouse, workshop	$20,000	
Draining-machine of 30 horse-power, placed on a boat	8,000	
Six boats for driving piles, at $1,600 each	9,600	
Three dredge-boats, of 35 horse-power, $12,000 each	36,000	
Two dredge-boats of 50 horse-power, $18,000 each	36,000	
Cost of tools and instruments, at 10 per cent. on first cost	30,000	
Single-track railroad and accessories	70,000	
Two locomotives	20,000	
Sundry buildings, administrator's house, lock-tenders' houses, stores, depots, workshop for the machinery, &c.	35,000	
		$264,600
The capital strictly necessary, resulting from what precedes, must therefore be of		2,221,569
But it would not be prudent, in hydraulic calculations, to place unlimited confidence in an estimate. In order to meet all omissions and unexpected casualties, it is wise to add 1-5 of the total amount, say		444,313
Which brings the total at		2,665,882

If we look back to the topographical description of the country given by us, it will be remembered that the canal crosses a region of low lands where the sea brings her alluvions, and which she sometimes destroys during her storm. The double dike of the canal, six miles in length, will break the efforts of the sea, and annul its swiftness in that section. The result will be that the lagoons will become real basins of precipitation, the bays will become lagoons, to be filled up in their turn, and the water will recede forever, letting a new continent rise.

A few years will be sufficient, even if we consider only the actual rapidity of the increase, to correct permanently and securely to the continent of the left bank of the river this archipelago now filled and leveled. Thereafter a belt levee, similar to that of the canal, is all that will be needed to protect this new soil from the inroads of the Gulf.

The river levee protecting it on the other side from the overflows of the Mississippi, we will have conquered from the sea a piece of land of nearly triangular shape, having six miles for the height of the triangle and about fifteen miles at its base, that is to say, a surface of about forty-five square miles. This surface, perfectly plain, formed of argilo-silicious alluvions, would probably be suited to all sorts of cultivation, admirably developed by the salted atmosphere, so soon as the soil would have been properly reclaimed from its saline conditions by periodical overflows of fresh water, regulated by means of sluices constructed in the levee of the river.

R. MONTAIGU.

D.

[Maps not printed.]

2.

REPORT OF BOARD OF ENGINEERS UPON CAPTAIN HOWELL'S PROJECT FOR A SHIP-CANAL CONNECTING THE MISSISSIPPI RIVER WITH THE GULF OF MEXICO.

The board of engineers constituted by Special Orders No. 83, dated Headquarters Corps of Engineers, Washington, D. C., June 30, 1873, to consider and report upon the plan submitted by Capt. C. W. Howell, Corps of Engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, in the navigable waters thereof, made in compliance with a resolution of the House of Representatives, passed March 14, 1871, have the honor to submit this report.

The resolution referred to is as follows, viz:

Resolved, That the Secretary of War be, and is hereby, requested to cause an examination and survey, with plans and estimates of cost, to be made by an officer of engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, or the navigable waters thereof, of suitable location and dimensions for military, naval, and commercial purposes, and that he report upon the feasibility of the same to the House of Representatives.

In compliance with the foregoing order the board met in the city of New York on the 25th day of last July, and held a number of meetings during that month, and subsequently thereto, as shown by the minutes of proceedings transmitted herewith.

At these several meetings there were examined and discussed not only Captain Howell's project for the Fort Saint Philip ship-canal, as set forth in considerable detail in his report of February, 14, 1873, and the accompanying charts and plans, but descriptions of and reports upon similar works successfully executed by European engineers.

It being deemed expedient, before giving a formal expression to their opinions, to visit and examine the site of the proposed canal, as well as to obtain the views of local engineers upon the subject under consideration, the board adjourned to meet in New Orleans.

The board accordingly re-assembled in that city on the 24th day of last November, and on the 25th proceeded down the Mississippi River, viewed the proposed location of the canal, and visited Forts Jackson and Saint Philip, both heavy structures, resting on an alluvial formation in all respects similar to that through and upon which the canal would have to be constructed.

The Southwest Pass was also visited, and the working of the dredge-boat at Pass à Loutre witnessed.

The opinions of distinguished local engineers were subsequently solicited, and those submitted in writing are attached to this report.

The views of prominent citizens of New Orleans interested in the commercial welfare of the Mississippi Valley were also obtained. They are fairly set forth in an article published in the New Orleans Daily Times, hereunto appended.

The conclusions formed by the board may be briefly stated as follows, viz:

1. From the facts and data presented in official reports and otherwise, from the experience gained on works of the same character, and the many improvements made in the practice of hydraulic engineering within the last twenty-five years, but, more particularly and pertinently, from the character of the borings made by Captain Howell upon the Fort Saint Philip Peninsula, across which the proposed canal is to run, the board is of the opinion that no extraordinary engineering difficulties in the construction and maintenance of the canal need be apprehended. But it is suggested in order to avoid beds and pockets of quicksand known to exist at some points in this locality, that the precise line of the canal should not be decided upon until a more

thorough examination of the sub-strata has been made by borings. It is not improbable that such an examination may indicate the expediency, and perhaps the necessity, not only of adopting a curve, or a series of curves, in preference to a straight line for the axis of the canal, but also of selecting other points of termini than those recommended by Captain Howell.

Indeed, one member of the board is in favor of locating the Gulf terminus to the northward, and consequently under the lee of Sable Point, and of securing the requisite depth of water into Isle au Breton Pass by dredging. This would naturally carry the river terminus nearer to Fort Saint Philip, and perhaps within suitable distance from the work to satisfy the requirements of a good defense without the erection of special works for that purpose. The question of affording adequate military protection to the outer end of the canal forcibly suggests the head of Isle au Breton Pass, north of Sable Point, as the proper point of outlet, for the reason that suitable defensive works can be established there at less cost than at any other point. But all those questions are deemed essentially subordinate. They must, of necessity, yield to the paramount consideration of adopting that locality for the canal which shall best secure the requisite stability for the sides and bottom of the prism and the foundations of the locks.

2. With regard to the plan submitted by the engineer in charge, he has stated that it was prepared while pressed with other important duties, and that, under the circumstances, it was not possible to perfect all details of the project, or to make the numerous borings which are considered a necessary preliminary to a precise location of the route of the canal throughout its entire length. The estimate submitted can therefore only be regarded as an approximation to the probable cost of the work.

3. The board approve the débouché of the canal into the Gulf waters of Isle au Breton Pass upon the ground that the advantages possessed by these waters of ample and permanent depth, and good and capacious anchorage grounds, are not only adequate to the objects in view, but are greatly superior to those which obtain in any other locality. A comparison of old charts with those that are more recent, both verified by Captain Howell's survey, shows quite conclusively that the depth of water in this pass, as well as upon the bar at its opening into the Gulf, is quite permanent; and the board coincide with Captain Howell's views that existing circumstances promise a continuance of deep water in this pass.

4. The board also approve the location of the inner end of the canal upon the straight portion of the Mississippi River below Fort Saint Philip, at such distance from that work as the final examination and borings shall indicate as most suitable, due weight being given to the question of providing adequate military protection for the work from existing fortifications, or otherwise, as may be found most advantageous.

[For a description of the canal, in order to understand the modifications recommended, reference may be made to Captain Howell's report, and the accompanying plans herewith returned.]

5. Captain Howell's project for the construction of the lift-lock contemplates a coffer-dam surrounding the entire lock. The board entertain doubts of the practicability of this method of construction at a reasonable cost, owing to the nature of the soil and the engineering difficulties consequent thereon.

In view of this circumstance, and upon a suggestion made by the senior officer of the board, it is believed the apprehended difficulties may be avoided by replacing the side walls of the lift-lock chamber

with gentle slopes of earth, and constructing the upper and lower lock-gates, with their foundations and side walls, separate from each other. With these changes the foundations of the ends of the lock can be laid by any one of the several processes well known to engineers. The bottom and sides of the lock-chamber should be riveted as far as necessary.

6. The following modifications of the proposed dimensions of the canal are recommended:

Length of lock-chamber increased to 500 feet.

Width of lock at the gates reduced to 60 to 65 feet.

Depth over sill, at extreme low water in the Gulf of Mexico, reduced to 25 feet.

Depth of trunk of canal, at extreme low water in Gulf, (not changed,) 27 feet.

Width of canal at bottom, (not changed,) 200 feet.

Sides of canal to slope about 1 upon 4.

A suitable arrangement of sluices must be made to meet these proposed changes.

The foundation and construction of the guard-lock may be the same as for one of the gates of the lift-lock.

7. The jettees, extending the canal into the deep waters of Isle au Breton Pass, will doubtless require more material than the plan submitted by Captain Howell contemplates; but inasmuch as the length of these jettees and their cubic contents depend, to no inconsiderable extent, upon the position selected for them, no very accurate estimate of their cost can be made until the final location is determined upon.

8. It is evident from the foregoing that the necessary and unavoidable absence of sufficient data to determine the best location for the line of the canal across the peninsula, including its termini, and particularly its débouché by jettees into Isle au Breton, renders it impossible to make a close estimate of its cost.

A new estimate, resulting in part from a revision of that made by Captain Howell, has been rendered specially necessary in view of the modifications of plan recommended by the board. It is believed to be ample to cover the cost of constructing a canal of the dimensions given above, located within the limits designated. The estimate amounts to $10,273,000.

The subject of the improvement of the passes at the mouths of the Mississippi will be separately presented.

Respectfully submitted.

New York, January 9, 1874.

JOHN NEWTON,
Lieut. Col. Engineers, Bvt. Maj. Gen., U. S. A.
Q. A. GILLMORE,
Maj. of Engineers, Bvt. Maj. Gen., U. S. A.
G. K. WARREN,
Maj. of Engineers, Brt. Maj. Gen., U. S. A.
WM. P. CRAIGHILL,
Maj. of Engineers, Brt. Lieut. Col., U. S. A.
G. WEITZEL,
Maj. of Engineers, Brt. Maj. Gen., U. S. A.
C. W. WORRELL,
Captain of Engineers, Brt. Maj., U. S. A.

Not fully concurring, my views will be presented in a separate report.

J. G. BARNARD,
Col. of Engineers, and Brt. Maj. Gen., U. S. A.

3.

NEW YORK, *January* 20, 1874

GENERAL: Having dissented from the views of the majority of the board of engineers convened by Special Orders, No. 83, June 30, 1873, to consider and report upon the plan submitted by Capt. C. W. Howell, corps of engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, I state, at the outset, that, in making separate reports upon the particular "plan" submitted, and upon the alternative of the "improvement of the passes," my object will be to prove—

1st. That *assuming* that a canal is to be *made*, the plan now submitted suffices only to show that a more protracted and more comprehensive study is required to fix the location and determine the *general* details of construction, and to make an estimate which can rightly be considered *approximate*.

2d. That before resorting to an artificial work of the difficult and costly character of a "ship-canal," a more attentive consideration of the superior advantages of the natural mouths, and of the fair probability of utilizing them, is needed.

Furthermore, I add, that neither difficulties nor costs are to be weighed against the demand for an adequate navigable outlet to the Mississippi River, whether that outlet be a canal or otherwise; but the "whether" here becomes, as I think I shall show, the symbol of a question not yet solved in favor of the canal.

The first proposer of a ship-canal appears to have been Mr. Benjamin Buisson, who, in 1832, suggested that a canal "six and a half miles long, commencing on the left bank of the river, a few miles below Fort Saint Philip, and entering the sea about four miles south of Breton Island, would afford an easy and safe access to the river to vessels drawing 20 feet." Subsequently, Lieut. B. Poole, a graduate of the Military Academy, serving as topographical engineer, surveyed (or, more accurately speaking, reconnoitered) this route, and reports (1837) that a canal here "offers a fairer prospect of opening the Mississippi to ships of the largest class than any other plan that has been spoken of."

But it remained for the late Major W. H. Chase, of the Corps of Engineers, to give the canal project a defined form by projecting in an official report dated February 9, 1837, what may be (though without drawings) properly styled a *plan* for "a ship-canal to connect the Mississippi River with the Gulf of Mexico." This plan is best exhibited by an extract from his report. He says:

> The obstacles presented to an easy entrance of the Mississippi by vessels drawing 12 feet of water, are productive of great injury to the commerce of New Orleans, and require to be promptly removed, or, *failing to be done*, the construction of a ship-canal on the plan indicated by Major Buisson, should be resorted to.
>
> By reference to chart, the line of the proposed canal is exhibited, commencing at a point about two and a half miles below Fort Jackson, and extending seven miles to the shores of the Gulf, and thence, by a jettee 1,760 yards, to 30 feet water. It is proposed to carry into effect this plan of a ship-canal—
>
> I. By a construction of a guard-lock at the junction of the canal with the river. The object is to prevent the flowing of the river into the canal.
>
> II. The excavation of the trunk of the canal, 100 feet wide at top, 30 feet wide at bottom, and 30 feet deep. The object of such large dimensions is at once to provide not only for the entrance of the largest ships engaged in commerce, but also of ships of war of the largest class. The advantages offering for both classes of vessels are obvious, and need no comment.
>
> III. The construction of the jettees or breakwaters of large dimensions, having for their base 100 feet, with a depth varying from 5 to 30 feet, and 20 feet wide at top, and raised to the level of high water.

The practicability of this plan depends solely on the question whether a lock of the dimensions required for the admission of the largest-sized vessels can be constructed on the banks of the Mississippi. I think the question may be easily answered in the affirmative, for we can refer to the practicability of excavating almost to any depth in the mud of the Mississippi Delta as exhibited at various works constructed by the United States, and by individual enterprise. At Fort Jackson, on the Mississippi River, the foundations were excavated to the depth of 12 feet, and were kept free from water by means of a small engine attached to pumps of considerable power.

The operations at Fort Jackson came frequently under my observation, and I am left in no doubt as to the perfect practicability of excavating to the depth of 30 feet, and also of the practicability of establishing a solid foundation by piling for the support of the walls of masonry necessary for the construction of a lock.

Taking for granted, therefore, that a lock can be constructed, we have only to consider the means of excavating the trunk of the canal and the construction of a shore breakwater. The marsh lying between the river and the Gulf, through which the line of the canal is located, is intersected by several bayous, all of shallow depth of water. Commencing at the river, it is proposed to excavate to a depth of 6 feet, affording sufficient water for the dredging-machine, which will thereafter be employed in the excavations, the canal being excavated to a depth of 6 feet through its extent.

The estimate was for a lock 200 feet long, 50 feet wide and 30 draught, of masonry, founded on 1,000 piles, a canal trunk 36,960 feet long, 30 feet wide at bottom, and 100 feet at top, and 30 feet deep, and two jettees, each one mile long, 1,000 feet apart, of dimensions already mentioned. A guard-lock at the sea end does not seem to have been provided for. Major Chase's estimate for workmenship was $8,619,299, increased to $10,000,000, to cover superintendence contingencies.

Twenty years later, R. Montaign, civil engineer, elaborated a plan, with considerable detail, for a canal on this identical location, with a masonry lift-lock 400 by 80, with 24 feet draught at low water, founded by means of coffer-dam on piles and grillage, a canal trunk six miles long, of identical dimensions, with "piers and moles" of peculiar construction, all of which he estimated to cost $2,665,882.

At the suggestion of Major Chase, the line of the projected canal was embraced by Captain Talcott in his great survey of 1838. "It resulted," says the latter, "in showing a fine ship-channel leading up to where he proposed it should debouch, and the perforation of the ground to a depth of 40 feet indicated a firm bottom of sand mixed with mud, tenacious of water, and altogether such as would be considered favorable for excavating, and on which there would be no difficulty in securing a foundation for locks or structures of any kind."

This canal project was reviewed by the late Chief of Topographical Engineers, Col. J. J. Abert, in his annual report, December, 1839. After some remarks on the "difficulty of making the excavation and keeping it free in this soft soil," he states that the execution of the locks "would constitute no insurmountable difficulty if this bottom" (*i. e.*, the "firm bottom of sand and mud" found by Captain Talcott) "was adequate to sustain the locks."

These are the only points he makes concerning engineering difficulties. But he goes on to say that the plan "would require a breakwater to protect the shipping in the bay between Sable Island and Isle au Breton from eastern weather;" and again, that the plan "is subject to a very weighty objection, independent of considerations in reference to the construction, which is, that it would be exposed to the efforts of an enemy, and would involve the Government in enormous expense for its protection. This consideration would, in my (his) judgment, justify the Government in its rejection, and would turn all its views back to the previously exposed methods of improving some one of the passes of the river."—(Colonel Abert's Report, 1839.)

The location of the canal project, now submitted to the board, is, to

all intents and purposes, identically that of Major Chase's. Yet these two considerations, made so prominent by the authority I have quoted, have not received any notice whatever in the project before us. The only reference to it in the report of the majority of the board is found in the following:

Indeed, one member of the board is in favor of locating the Gulf terminus to the northward and consequently under the lee of Sable Point, and of securing the requisite depth of water into Isle au Breton Pass by dredging. This would naturally carry the river terminus nearer to Fort Saint Philip, and perhaps within suitable distance of that work to satisfy the requirements of a good defense, without the erection of special works for that purpose. The question of affording adequate military protection to the outer end of the canal forcibly suggests the head of Isle au Breton Pass, north of Sable Point, as the proper point of outlet, for the reason that suitable defensive works can be established there at less cost than at any other point. But all these questions are deemed essentially subordinate. They must of necessity yield to the paramount consideration of adopting that locality for the canal which shall best secure the requisite stability for the sides and bottom of the prism and the foundations of the locks, * * * * and after approving "the debouch into the Gulf waters of Isle au Breton Pass," &c., &c., "the board also approve the location of the inner end of the canal upon the straight portion of the Mississippi River below Fort Saint Philip, at such distance from that work as the final examination and borings shall indicate as most suitable, due weight being given to the question of providing adequate military protection for the work from existing fortifications or otherwise, as may be found most advantageous."

These paragraphs either suggest important changes of location, or they do not. From anything experience or borings into the soil has revealed, I do not consider as "paramount," in determining that location, the matters so characterized. There would be grave "difficulties," indeed, in obtaining "requisite stability for the sides and bottom of the prism, and the foundations of the locks," if, as stated, matters so important as the accessibility of the canal entrance in "eastern weather," the protection of the canal-mouth, and of shipping in the roadstead against the violence of waves, and the protection of the canal-works against the maritime enemy during war, all absolutely essential and unprovided for in the project, are "essentially subordinate" to overcoming such difficulties, or to facility of dealing with them.

When it is borne in mind that the identical location of four different engineers (Captain Howell included) was governed by the "paramount consideration," (*and a very sound one by itself,*) of the *shortest distance from the river to deep-sea water*, it is scarcely comprehensible that other considerations important enough to be weighed with *this* become "subordinate" to difficulties of the ground. If so, the bare practicability even of the present location is rendered doubtful.

Neither observation of, and familiarity with, engineering works in Louisiana, nor the borings made by Captain Howell, suggest to me that any *material* variation of its location will be suggested by further scrutiny of the sub-strata, by boring. My knowledge of the soil, indeed, prompts me to affirm that, so far as the "foundations of the locks" are concerned, (I do not allude, of course, to abrasion by the river,) the bearing-power of the soil is not likely to be found better or worse in one place than another. Captain Talcott found at forty feet a "firm bottom of sand mixed with mud,"* (*clay*, probably,) and the borings made by Captain Howell after passing through various mixtures or strata of "blue clay" and "sand," exhibit generally, at about forty feet, a stratum of indefinite depth of blue clay, with little and sometimes no sand. This stratum possesses, however, in all probability, no greater "bearing" qualities than any of the others. Pure blue clay was found at Fort Livingston,

* I think Captain Talcott meant to say that *throughout* his forty feet of perforation he found sand mixed with mud, (or clay,) which he regarded as "firm bottom."

(underlying nearly pure and incompressible sand,) at depths of from twenty to twenty-five feet. Few works in Louisiana have settled more than Fort Livingston, and there are good reasons for believing that th yielding occurred in the clay. Major Turnbull found at the site of the New Orleans custom-house, after a few feet (three or four) of light surface-matter, "stiff blue clay" slightly mixed with very fine sand, extending to depth of boring, (27 feet,) and yet that custom-house, the walls of which rest on grillages 15 feet wide, has settled nearly 2 feet. Forts Jackson and Saint Philip rest on higher strata than this 40-foot stratum. Their settlement has been great, but not so great as that of Fort Livingston.

The strata, therefore, whether superficial or deep, are (so far as we know) all equally yielding. The mobility of the "fine sand," where it exists, as it sometimes does, in strata almost destitute of clay, may, indeed, enhance the difficulties of *making* the canal-trunk, and of *getting through them* to reach the lock-foundation, but it is *not likely* that any *considerable* change of location should result.

The engineering difficulties, therefore, great as they may be, have no claim to being "paramount" in the location of this canal; they are likely to have but trifling influence upon it, and are wholly subordinate to the considerations of *accessibility*—protection of its harbor *against the sea*—protection of its works *against the enemy*. The late Colonel Abert has officially affirmed that the canal, as located in the project before us, was not only *unprotected* in both these relations, but that it would demand works of such expense as to justify the Government in rejecting it, and in turning its attention to the improvement of the passes.

I do not affirm *this*; I merely say that the plan which does not treat these matters at all is not a sufficiently complete study of the project.

The first formal suggestion of a very radical change of location of the canal came from one of the professional gentlemen whom the board consulted in New Orleans—an engineer whose professional life has been identified with the military defenses of the delta of the Mississippi River, and with the great engineering questions which the control and navigation of its waters perennially raise. (See letter of Gen. G. T. Beauregard.) "Its location," he says, "on the river should be under the protection of the guns of Forts Saint Philip and Jackson, due regard being had to the permanency of the river-bank." In a draught of a report I prepared in New Orleans, and communicated to the members of the board, I suggested "whether a location from Saint Philip to somewhere near Deep-Water Point, and the dredging of a small harbor connecting with Breton Bay, (in 10 feet water,) and under the shelter of Sable Island, might not be better than bringing the canal direct into the bay, where now proposed. Such a harbor would, while tolerably sheltered, be much more easily defended against a maritime enemy."

The member of the board "in favor of locating the Gulf terminus northward and under the lee of Sable Point, * * * which would naturally carry the river terminus nearer to Fort Saint Philip, and perhaps within suitable distance to satisfy the requirements of a good defense, *without the erection of special works for that purpose*," is understood to be one of the signers of the majority report.

The suggestions "or opinions" above cited all involve *radical change of location*. They come, therefore, from three different sources, two of which are members of the board, and the third entitled to great consideration, for reasons already given. But I go further in *suggestion*. A canal starting a few hundred yards below Fort Saint Philip, and taking a direction due north, (nearly,) would strike the Gulf waters at two miles

distance, and the 6-foot curve at two miles and three-quarters; thence, on a line directly north to Hog Island, three miles distant, the water attains depths of 10 to 12 feet. A *dredged* harbor of the magnitude of that of the North Sea Canal (*i. e*, the dredged portion, say about two-thirds of a million superficial yards, or 136 acres) would not be an undertaking of unreasonable magnitude. It would be perfectly sheltered from storm-waves, while a dredged channel in water varying from 12 to 25 feet depth, of about five miles length, would constitute the communication to the deep waters of Breton Island Bay. The experience of dredged channels of approach to Baltimore, 24 feet deep, (ten miles, of which five miles is wholly dredged, the rest partially,) and of Atchafalaya Bay, (twelve miles long, to about eleven feet depth,) prove the efficiency of such channels. Instead of six miles of canal, there would be but two. Instead of two jettees of a mile length each, of which the cost is so formidable an item, there would be but the bulkheads (of masonry, riprap or otherwise) from the shore-line to edge of the dredged harbor. The canal, for its whole length, would be "under the protection of the guns of Forts Saint Philip and Jackson."

The anchorage of Breton Island Bay would still be as available as now. The defense of that anchorage and of the dredged channel approach suggests the desirableness of a work on Sable Point, but *this* defense is quite another matter from that of the canal itself, though rendered essential by its existence.

It is not necessary for me to *affirm* that the location and arrangement above suggested are better than that of Major Howell, Major Chase, and others. I have only to refer to the grave objections to the latter, enumerated by the late chief of Topographical Engineers, to set forth substantial reasons for my position that "a more protracted and comprehensive study is required to fix the location."

In turning now from the matter of *location* to that of plans of construction, I do not know how I can discharge the duty "to consider and report upon the plan submitted" to the board without saying that it is not one upon which it would be proper to undertake the execution of the work, nor one in which the great problems of the canal construction are adequately solved. The majority of the board entertain doubts of the practicability (at a reasonable cost) of the method of a coffer-dam surrounding the entire lock, "owing to the nature of the soil and the engineering difficulties consequent thereon." But even if the engineering difficulties be overcome, the foundation proposed is quite inadequate. A grillage covering a surface of 112 by 550 feet (about,) and only 6 feet thick, would be perfectly impotent to distribute pressure or to prevent distortion and cracking.*

Furthermore, I am of opinion that no thickness, within practicable limits, of grillage *alone* will suffice to keep such a lock free from distortion and injurious settlement. This opinion is founded upon the compressible character of the clay substratum, (as already explained,) which invariably yields to superimposed weight, even if very slight. Mere settle-

* Simply as a confirmation, (for I did not first base my opinion on an individual instance which had passed out of my mind,) I quote the following note, taken fourteen years ago at the Helder, (Holland:) "The new dry-dock is 350 feet long by 90 feet, (interior dimensions.) The site was excavated, the water pumped out, (the soil as deep as I could see it, which was about to the level of the bottom of the dock-floor, was mixed strata of sand and clay,) then a grillage of timbers, three yards thick. The structure had been completed up to two-thirds, perhaps, of its full height. The weight of the side-walls had caused a wide longitudinal crack through the middle, the whole length of the dock, perhaps an inch or two wide. They had cut out the old lining and bottom arch, and were rebuilding it. The brick masonry was well laid; the bricks indifferent, and the mortar not as hard as our cement mortars."

ment is not necessarily destructive of masonry structures in general, but the working of large lock-gates demands not only the most perfect freedom from distortion, but the most perfect level. As a simple means of escaping the difficulties of a deep construction so extensive, I recommended the isolated construction of the masonry gate-chambers. But, *for these* the maximum stability, *only* to be attained by the important auxiliary of piling, is *indispensable.** Piling can be done without encountering the engineering difficulties of the coffer-dam process, and the masonry can be built, and lock-gates hung, whether by the pneumatic or some other method more simple and less costly. The lock dimensions (of the plan) have been modified by the majority in their report, and judiciously, I think.

The jettee construction of the plan is described by the engineer as "one of a *substantial* though *temporary* character, and must be superseded by one of béton, based on the foundation this one will afford."

Even if economy of time justify a "temporary" construction, the one designed would, I think, prove inadequate, and the enormous expenditure upon the so rapidly-perishing timber work, $1,000,000, could not be regarded as judicious. Of course, there is *no basis* afforded for estimating the cost of the *permanent* jetees with which the work must be provided.

By reference to the project of Major Chase, it will be seen that *he* places his jettees (of a massiveness fully adequate) 1,000 feet apart, dredging the whole space between them. This arrangement provides for something like a *harbor*, and although the objection of eastern exposure is so strongly urged by Colonel Abert, the feature cited furnishes a palliative not found in the present plan.

Breton Island Bay is exactly opened to the prevailing storm-winds of the Gulf; and should *this* location be adopted, I think there can be no doubt of the necessity of creating, by the arrangement of these jettees, (starting from points on shore 1,000 or 1,200 yards distant, and converging toward the outlet,) a small artificial harbor, as at the entrance to the North Sea Canal.

Thus far, experience in Louisiana offers no example of the cutting of a canal to a depth of 25 feet, unless it be, indeed, the occasional river "cut-offs," which excavate to much greater depth. That the "prism" can be made and maintained I do not doubt, but I *do* doubt whether that result, including the protection of the sides,† formation of embankments, roadways, &c., will be attained for the total arising from an estimate of fifty cents for each cubic yard, within the defined limits of the excavated section. I doubt, however, the necessity of a bottom width so great as 200 feet. The North Sea Canal, three times the length, has but ninety feet bottom-width. This dimension is one easily increased, if experience show the necessity.

In conclusion, I would say that while I do not doubt the entire "practicability" of the canal construction, I think that the phraseology used in the report of the majority, that "no extraordinary engineering difficulties need be apprehended," rather underrates the real difficulties to be anticipated. The sinking of the extensive masonry masses to a

* The plan of Major Chase—and nothing which has succeeded this plan, so boldly and sharply defined, has been any advance—contemplated piling; so did that of his follower and (probably) imitator, Montalgu. The locks in the Y of the North Sea Canal, resting on strata of similar character, are piled.

† Sailing-vessels will, of course, be towed through the canal. *That* expense should not be imposed upon steam-vessels, which, of large dimensions and draught, are superseding sailers for ocean navigation.

depth of more than 40 feet below the contiguous river-surface is something which has no actual precedent in Louisiana, and demands the most careful study before undertaking, and will task the skill of the engineer in execution.

The climate itself, in conjunction with the marshy soil through which the work is laid, is no *ordinary* difficulty, unless, indeed, the work be suspended for four or five months of the year. The assembling of large bodies of men on that site and under that sun, the turning up of marsh soil, impregnated with vegetable matter, cannot fail to generate their incidental diseases, and cause mortality which may hamper the progress, while the fatal epidemic of the country, unaided by such helps, would be likely to cause protracted interruptions of the work.

I do not wish to exaggerate in the slightest degree the difficulties and costs of the work, nor to deny that, if the navigation and commerce of the Mississippi cannot otherwise be adequately provided for, it can be made and should be made.

But if the execution is not to be entered upon regardless of cost and blindly as to ultimate requirements, the location must first be fixed by a wider range of considerations and study, and the plans (depending, of course, upon the location *thus fixed*) carefully matured after experimental examination of the site by careful comparison of available methods of overcoming the difficulties the character of the site reveals; and, moreover, *all that the canal project carries with it as indispensable accessories* must be planned in relation to it and enter into the estimate. Fortifications are among these indispensable accessories; so will be also some breakwater auxiliary or artificial harbor; so will certainly be the *cost of maintenance*.

Referring to the experience of other canals with locks, (the Erie may be cited,) it would not be safe to estimate this maintenance at less per annum than 2 per cent. upon the total cost for this canal.*

I have thus endeavored to prove that the plan submitted to the board suffices "only to show that a more protracted and more comprehensive study is required to fix the location and determine the *general* details of construction, and to make an estimate which can rightly be considered as *approximate*."

I shall, in another report, maintain that, "before resorting to an artificial work of the difficult and costly character of a ship-canal, a more attentive consideration of the superior advantages of the natural mouths, and of the fair probability of utilizing them, is needed."

Respectfully submitted.

J. G. BARNARD,
Colonel of Engineers and Brevet Major-General.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

ARMY BUILDING,
New York, January 28, 1874.

GENERAL: I herewith forward two sketches† which I desire to have attached to, and made a part of, my report on the "plan submitted by Capt. C. W. Howell, Corps of Engineers, for a ship-canal," &c.

* This estimate is made with full consideration of the fact that there are no embankments, no leakage, and no "puddling" in the proposed canal; the maintenance, &c., of fortifications not included.

† For sketches see original.

No. 1 is intended to illustrate the quotations from the report (1839) of the late Col. J. J. Abert, which urges the necessity of shelter to the entrance during "eastern weather."

No. 2 is intended for reference in reading what is said concerning the question of location and of defense by *existing fortifications*.

Very respectfully, your most obedient,

J. G. BARNARD,
Colonel of Engineers and Brevet Major-General.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

4.

NEW YORK, *January* 13, 1874.

The board of engineers convened by Special Orders No. 83, headquarters, Corps of Engineers, Washington, D. C., dated June 30, 1873, to report upon the project of a ship-canal to connect the Mississippi River with the deep waters of the Gulf of Mexico, having had the matter referred to them extended by the following instructions, viz:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 3, 1873.

SIR: In reply to your letter of the 24th ultimo, I am directed by the Chief of Engineers to say that it is allowable and desirable to have the views of the board of engineers on the question as to the expediency of improving the navigable outlet of the Mississippi, by the Fort Saint Philip Canal, as an alternative to, or a simultaneous measure, perhaps, with the improvement of the passes.

The report of Captain Talcott, of January 30, is in the hands of the copyist, and will be furnished you as soon as possible.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Col. J. G. BARNARD,
Corps of Engineers, Army Building, New York City.

have the honor to submit this report:

The improvement of the passes has usually been discussed in reference to the application to them of the jettee system, or of dredging, in conjunction with each other, or separately, and the board propose to confine their attention to these methods.

The depth of water over the bar to serve for commercial, naval, and military purposes, it is assumed, should be the same as that selected for the draught over the miter sill of the proposed ship canal, viz, 25 feet at extreme low water of the Gulf. The pass to be improved is assumed to be Pass à Loutre; this having been selected by several engineers, advocating the improvement of the mouths of the Mississippi, as the best adapted to the application of the jettee system.

In order to advance the low-water twenty-five-foot curve of the channel of the pass from the point where this depth ceases to obtain, to the bar, it would be necessary to construct parallel jettees, ofthe same distance apart as the shore-lines of the pass where the required depth is excavated.

These considerations fix the length of each jettee at about 24,000 feet and the distance apart 2,200 feet.

The top of the jettees must be held low, not higher than the banks from which they extend, because additional height, while adding to their cost, would not induce the passage of more water between them so long as the banks of the river above are at a lower level. An elevation of the jettees above the banks from which they spring would, in fact, en-

danger the latter in the presence of a rise overtopping them, especially at the points where the jettees and banks unite.

The debouch of Pass à Loutre by two mouths makes it necessary to close one of them, and this operation is supposed to be performed by the north jettee, constructed across the northern mouth.

An inspection of the map of the pass, to fix in the mind the necessary course of the northern jettee, will show that the present direction of the running waters will be deflected by this work, which forms a concave bend, to receive them, and a considerable scour of the bank must necessarily ensue, causing the foundation of the jettee to be undermined, unless effective measures are taken to prevent such catastrophe.

The board are unable at this time to suggest any remedy, except to sink the foundations deep enough to be out of reach of these influences. As to how great this depth should be to insure safety, the board have no certain means of judging, but it may be 25 feet, or even more.

The closing of the northern mouth, which, following the line of jettee, would be a work operating to deflect the present direction of the currents, and over 7,000 feet in length, is an undertaking of great delicacy, the cost of which, in a soil of the character pertaining to this locality, might prove to be excessive. Success in this operation is, however, necessary to the application of the jettee system to the pass under consideration, and must be sought at whatever cost, in order to accomplish the desired improvement of navigation. (Note A.)

It is important to say that the advance of the jettees, step by step, will cause deep holes to form at their extremities, due to the escape of the waters as soon as released, and a consequent excavation of the loose soil, which will much increase the depth and cost of these works.

The dislodgment, by the operation of the jettees, of the immense quantities of material from the sides and bottom of the channel, would bring the scouring force into contact with the interior of the banks and shoals, which consist generally of soil inferior in hardness and firmness; and it would be impossible so to fix the limits of this distributing action that it might not often reach the jettees themselves.

The long, low banks and the shoals of the delta do not owe their existence or permanence to anything inherent in the strength and consistence of the soil composing them—for on these points all testimony agrees—but upon the action of the waves and currents, constituting an area of equilibrium, in which the particles are deposited and retained.

But as these forces are not always, as to effect, but only periodically, in equilibrium, it necessarily follows that changes in the shoals and banks are constantly occurring, not enough, indeed, to interfere with the general development of the delta, which appears to advance by virtue of uniform laws, but quite sufficient to endanger and even destroy the most skillfully-designed works. (Note B.)

This consideration of the unstable and treacherous nature of the shoals and banks is necessary in order to fix the mind upon the cost and risk as well as upon the disappointment which would likely attend an attempt, upon such foundations, to construct works to coerce or control the currents of the passes.

An estimate has been prepared by Captain Howell, engineer in charge of the jettees described in this report, supposing them to rest upon the natural bottom, without settlement, as follows:

Fascines and ballast, at $5 per cubic yard	$2,545,220 00
Riprap stone, at $7 per ton	2,241,097 60
Total	4,786,317 60

If settlement and the other probabilities enhancing the cost of this work, as already discussed, be considered, it appears entirely within limits to state that the above estimate should be doubled.

Assuming that it will take about four years to complete the jettees to the present 25-foot curve outside the bar, and estimating the least yearly advance of the bar at 250 feet, it would be proper to add to the estimate already the cost of 2,000 linear feet, equal to $68,888.

There is, besides, the estimate for future annual extensions to keep pace with an increased advance of the bar, which by the same authority would be $1,613 per linear foot of jettee.

The next step in order is to consider the effects of these jettees, supposed to terminate at the curve of 25 feet outside the bar, upon the depth of water in the channel and upon the bar; and it will be first supposed that the jettees, if projected too far apart, should near the bar be brought together sufficiently close to insure the desired scouring effect upon the bar.

Would this state of things, thus produced, endure for a considerable time, or for a period sufficient to fill up the deep space ahead in the Gulf to a distance equal to the present interval between the termination of the 25-foot curve in the channel and the outer crest of the bar?

The principles upon which a reply to these questions depend have been exhaustively treated in Chapter VIII of Humphreys and Abbot's report on the physics and hydraulics of the Mississippi River; and there is nothing more to add, except the conclusions which follow from that report.

Let us suppose, as the first effects of the jettees, the 25-foot curve to have advanced to the original outer crest of the bar. It will be found that the position of the crest has already advanced, due to the large amount excavated from the sides and bottom of the channel and the ordinary supply of materials which are rolled on the bottom and deposited on the outer slope; and it is not certain that there would be a full depth of 25 feet at the new crest, on account of the tendency to form the upper surface of this deposit coinciding with the angle at which the river waters emerging from between the pier-heads would be deflected upwards by the waters of the Gulf, an effect which the spread of the river waters, after their release from the confinement of the jettees, would increase. The succeeding flood, while advancing the bar, should upon the same principles still further decrease the depth over its outer crest; and every advance of the bar would be followed by a similar result. Thence the jettees, in order to retain the depth gained, should keep pace in their extension with the progress of the bar. At high water of river the deposits are made exteriorly, at low water, interiorly. During the changes from high to low water, the deposits are made between these two, or on what is ordinarily considered the bar.

A condition of things likely to occur periodically, whereby a medium stage of the river, without high floods, might be maintained, would cause unusual deposits upon the bar; and hence an additional reason for the conclusion, apparent already from the first portion of this discussion upon the bar, that in order to secure, at all times, a depth of 25 feet, provision should be made in the arrangement of the jettees to excavate to a depth greater than that. (Note C.)

As a case in point, Major Stokes, royal engineers, in his paper upon the improvement of the Sulina mouth of the Danube, states, in 1863, owing to the absence of floods in the river, a bank formed within the pier-heads almost in the position of the old bar, greatly contracting the channel, though not actually barring it.

If it is not already apparent that the deep space ahead will not of itself prevent the restoration of a shoal depth to the bar, after once deepening it, reference may be had to the fact that a shoal bar, for over one hundred years, has been advancing at Pass à Loutre, over a deep space ahead, and at an average rate of about 300 feet a year.

In proportion as the cross-section of discharge on the outer crest of the deposit widens, its progress into the Gulf will become slower, and the depth of water upon it will constantly decrease.

(Humphreys & Abbott, pp. 446 & 447.) On the other hand, if the cross-section be narrowed, the progress into the Gulf of the deposits will become more rapid.

This rapid extension of the pass into the Gulf would tend to increase the volumes of the shorter passes at the expense of its own, and it would eventually be necessary to resort to another pass for the continuance of the plan. (Ibid, p. 456.)

This yearly progress of the bar demands a corresponding extension of the jettees into deep water opposed to the severe storms of the Gulf, and consequently of great cost.

The difficulties at the mouth of the Mississippi, so far as concerns the improvement by jettees, resolve themselves into three sources.

1. The absence of a littoral current.
2. The yielding nature of the banks and shoals.
3. The abundance of deposits.

The first and third combine in the yearly and rapid extension of the bar, and compel the works of improvement to continue at a heavy annual cost until their entire abandonment.

The second makes their construction difficult and their maintenance improbable, unless deeply founded at a very heavy expense.

All the principal objections to the improvement of Pass à Loutre necessarily apply to the Southwest Pass.

But the board does not clearly understand why Pass à Loutre has been preferred for improvement by jettees, its exposure to the storms and storm-tides of the Gulf being much greater than that of the Southwest Pass; and it may be added that the direction of jettees at the Southwest Pass would be straight, while at the other pass they would be inclined to the direction of the current, which is objectionable.

Pass à Loutre, however, has the advantage of being directly in the track of vessels bound to and from the East. The lengths of both jettees at Southwest Pass, designed for the same objects as at Pass à Loutre, would amount to 54,000 linear feet. It is proper to state that these lengths were taken from a Coast Survey map, of a scale smaller than that of the map of Pass à Loutre, made by the engineer in charge for the operations of the dredging-machine, and upon which the improvement of Pass à Loutre was discussed by the board.

In the study of improvements of this character it is well to refer to instances where trial has been made, holding in view always the sound principles that the fact of work having proved successful, or having failed, at any river mouth, by no means insures that the same kind of works will succeed or fail at any other river mouth unless the very same conditions exist.

The board is indebted to the article (vol. XIII, professional papers) of Major Stokes, R. E., British commissioner for the improvement of the mouths of the Danube, for much of the matter in the present discussion immediately following.

From 1594 to 1682 attempts were made to improve the Vistula by extending piers seaward from its mouth. "A breach in the root of this pier, through which the river cut itself a lateral communication with the gulf 10 or 12 feet deep, suggested the idea of obtaining a permanent channel independent of the mouth."

The extension of the piers from the mouth of this new channel converting it into a canal did not avail to secure the requisite draught. "The author was informed by the engineer who, in 1858, had charge of all the Prussian harbor works, that no efforts were available to keep open a greater depth than 10 feet into the canal before the year 1840. * * * It was not till after the breaking through of another mouth several miles to the east, in 1840, as before mentioned, that the Prussian engineers could congratulate themselves on having obtained a good entrance to the port of Dantzic. * * * The river was at once shut off from its old course * * * by a dam. * * * The old mouth was cut off from the sea by a solid dam. * * * By these means an excellent channel of 17 feet was obtained," (at the mouth of the canal,) "and has since been maintained by constant dredging. As already mentioned the dredging is carried on under peculiar favorable circumstances, as the Gulf of Dantzic is land-locked. * * * In the Gulf of Dantzic there can hardly be said to exist a littoral current. The littoral current of the Baltic, from west to east, passes along the Helas * * * and strikes again the coast, which then immediately tends to the north. The main force of the current is then carried northward, but a portion of it sets into the Gulf of Dantzic from east to west, * * * while a second current, passing round the head of the Helas, sweeps along the shore of the Gulf, and, travelling from west to east, meets the main current somewhere opposite the old mouth. No more unfavorable circumstances for the opening of the mouth of the river could be imagined. The river issuing into slack-water at the meeting of the two currents threw down its deposits at once." * * *

The two attempts, which were persevered in for more than one hundred and fifty years, to keep a channel open for sea-going vessels at the mouth of the river or of the canal, failed, and it was not until the fortuitous opening of another mouth, five miles from the old mouth, which removed the deposits to a distance, that a success was obtained.

The causes of non-success were:

1. Absence of neutralization of littoral currents.
2. Abundance of deposits.

The causes of final success were:

1. A stoppage of deposits.
2. Dredging in a sheltered gulf.

The character of the piers, which were chiefly built of riprap, as shown in the plates accompanying this article, indicates that the foundations were not of the yielding nature of the Mississippi deposits, and as there is no mention made of difficulties arising from the nature of the bed, it is assumed to have been ordinarily good.

The board passes to another instance of improvement, cited from the same author, of the mouths of rivers in tideless seas viz, the Sulina mouth of the Danube.

The improvement was made by the construction of parallel piers.

The north pier is a continuation of the left bank of the river. It is 4,640 feet in length, and is carried out to what was the 16-foot line before the work was even begun. * * *

The south pier approaches the north pier on a curve, and then runs parallel with it, terminating 600 feet short of the other pier.

The construction was of an outer line of sheet piling stayed by a framing of piles and timbers, the foot of the sheet piling being protected on both sides by a large deposit or bank of stone rising to the level of the water. At intervals there was an inner row of sheet piling,

with cross lines to the outer row, the space or box thus formed being filled with stone, and both rows protected on their exterior by a deposit of stone.

Since the construction of piers the depth has never been less than 16 feet, and is usually 17 feet, there having been at times a good channel of 17½ feet.

The piers were finished in 1861, and in 1863, the date of the article, the experience was that the depth varied at times from 16 to 17½ feet, the latter belonging to the floods of "unusual violence."

Spring floods of that year had formed a menacing bank on the continuation of the north pier, and about 2,500 feet to seaward of it, but this bank was speedily broken down by the spring gales and carried away by the littoral currents. In 1862 the floods threw down a similar bank, but without obstructing the navigation, and that bank was again removed by the action of storms and currents. * * * The rapidity with which they were removed seems to favor the supposition that the bar will only creep across the front piers when the general advance of the delta should have pushed the littoral current further away from them, and thus have caused a double effect dangerous to the channel.

In the first place, the river current would not then be turned southward, and would throw down its deposits immediately in front of the piers; * * * and, secondly, the banks thus formed, instead of being broken down by the gales and carried southward, would be driven back on the channel, which they would still more choke.

Since this article was published, it is ascertained that the south pier has been extended as far seaward as the north, and that a depth of 20 feet has been obtained.

The board are not in possession of a paper on the same subject, by Sir Charles Hartley, the distinguished engineer who constructed these piers, but it is impossible to entertain a question as to the causes of the success of the pier system at this place.

An inspection of the map accompanying the article shows a great development of the delta form at the Kilia mouths, and the same formation to a less degree at the St. George mouth, with a consequent projection outward of the shore-line, but at the Sulina mouth no formation of the kind is distinctly traceable, and it is inferred, though the fact is not material, that the quantity of sediment emptied at this outlet is small in comparison with the others.

The construction of the piers indicates a difference in the character of the bed, as to resistance, from that of the Mississippi, it being certain that this description of work would not answer at the latter place.

The cases of the Vistula and the Sulina mouth of the Danube manifest essential points of divergence from the circumstances attending the improvement of the Mississippi, and the results obtained in the former cases constitute no precedent for the employment of the same means at the latter place.

Upon a review of the practical difficulties which the adoption of the jettee system of improvement at the mouth of the Mississippi would entail, and a due consideration of the original cost of construction and of annual extension, entertaining doubts, moreover, of the successful issue of the attempt, the board do not consider it advisable to recommend it.

With regard to the cost of this operation, owing to the uncertain nature of the problem, made so by the peculiar risks attending it, the board find it impossible to fix any reliable limits.

The estimate in this report, made upon a hypothesis favorable to the project, indeed, but which does not exist, is useful only to convey to the mind some idea of the magnitude of the undertaking.

As an auxiliary to the improvement by jettees of the mouths, dredge-boats must be employed to remove mud-lumps.

The other means of improving the depth at the mouths, by the stirring-up process, has already been put to the test of practice.

Two boats, the Essayons and the McAlester, have operated upon Southwest Pass and upon Pass à Loutre.

These dredges can begin work upon a bar having only 11 feet of water. The former can excavate to a depth of 20 feet, the latter boat to a depth of 22 feet.

Operations at Southwest Pass between July 1, 1872, and April 1, 1873: The width of the channel made, varied from 50 to 150 feet. The depth varied from 20 to 13 feet. For 39½ days, 19 to 20 feet in depth; for 120 days, 17½ to 19 feet in depth; for 90 days, 17 feet in depth; for 22 days, 13 to 16½ feet in depth.

The smaller depths, from 13 to and including 17 feet, were due mainly to blockades and other obstructions formed by grounding vessels.

From July 1, 1872, to April 1, 1873, 53 vessels grounded at Southwest Pass, and were the cause of there being less than 18 feet in the channel after November 1. To April 1, 1873, the dredges worked 58 days. Suspension of work on account of slack current, 62 days; fogs, 21 days; waves, 16 days; repairing, 36 days. The remainder of the time is accounted for in coaling, pulling grounded vessels out of the way, and suspension of work on Sundays.

Operations at Pass à Loutre from April 1 to June 30, 1873: Starting at 11½ feet depth on the bar, worked 78 days. From May 27 to July 1 the depth was 17½ feet at extreme low water of the Gulf.

This favorable comparison of working-days at Pass à Loutre is due to several causes, viz, the small number of vessels passing through; the absence of grounding; the protection which the outer shoals afford to the bar, and the sufficiency of the currents during the period in question.

It should be noted that the stoppages were from causes beyond control, and, consequently, which could not be remedied by better boats or more of them. The grounding of boats, the stoppages, and the shoaling in consequence thereof, could, however, have been prevented in many cases by good regulations well enforced.

The effect of the stirring-up process is to sift out the finer, leaving on the bottom the heavier, sandy particles, thus forming a surface harder than the natural one of the bar. Nevertheless, vessels pulled with powerful tugs are drawn through with a draught greater by one foot than the depth of channel. This operation would not generally succeed with long sea-going steamers.

The results so far do not warrant the board in estimating a greater depth than 18 feet at extreme low water as capable of being maintained at the passes by means of the stirring process. This is inadequate to the requirements of the naval, military, and commercial services.

Although the stirring-up process cannot, therefore, be made a substitute for a project affording the proper depth, it should be continued until such project shall have been completed.

It is understood that one member of the board of 1852, Major Chase, (now deceased,) was in favor of the canal project,(Note D.) Another member, Major Beauregard, has expressed his opinion very emphatically in favor of a ship-canal, and doubtfully as to the jettee system. This testimony is valuable, as springing from the matured judgment of an experienced engineer, well acquainted with the subject he discusses, and is an evidence of a prevailing conviction which points to the fact that the time has come for obtaining an outlet to the ocean of depth sufficient to

meet the necessities of the great valley of the Mississippi, and that the canal offers the best and most certain means of attaining this result.

JOHN NEWTON,
Lieutenant-Colonel of Engineers, Brevet Major-General.
Q. A. GILLMORE,
Major of Engineers, Brevet Major-General.
WM. P. CRAIGHILL,
Major of Engineers.
G. WEITZEL,
Major of Engineers, Brevet Major-General.
C. W. HOWELL,
Captain of Engineers, Brevet Major.

Not fully concurring in the above, my views will be submitted in a separate report.

J. G. BARNARD,
Colonel of Engineers and Brevet Major-General.

Dissenting from the report of the board in but one point of opinion, I have signed the report, reserving mention. Referring to my report on the canal, also to my answer to a letter addressed me by the president of the board, both submitted with the report of the board, it will be observed, as the probable depth of channel to be maintained by dredging on the bars under stated conditions, I name 20 feet. This is considered by the board an over-sanguine estimate, more especially since the past record of dredging does not show the maintenance of an 18-foot channel.

While adhering to my opinion, I must acknowledge, so far as I know, I am the only engineer holding it.

C. W. HOWELL,
Captain of Engineers, U. S. A.

NOTE A.—The operation of closing the north mouth by a work which at the same time changes the direction of the current, appears to be doubtful of success, as well as excessive in cost; and the question arises whether it would not be better first to close the mouth by a dam below the position of the works and then to construct the line of jettee. In this way the difficulties would be separately met, and the cost might be kept within limits capable of being fixed.

NOTE B.—The influence of the jettees will develop additional forces tending to change the form and equilibrium of the shoals.

NOTE C.—And hence the jettees, in order to carry into the Gulf a depth greater than 25 feet, must be of greater length, at a less distance apart, founded in deeper water, and situated further down the slope of the banks, all of which circumstances are unfavorable, as to the cost and difficulties of construction.

NOTE D.—Major Chase had, in 1837, submitted a project and estimate for a ship-canal.

5.

ARMY BUILDING,
New York, January 29, 1874.

GENERAL: In a partial report, January 20, confined to the discussion of the "*plan* submitted by Capt. C. W. Howell, Corps of Engineers, for

a ship-canal to connect the Mississippi River with the Gulf of Mexico," I stated that in another report "I shall maintain that before resorting to an artificial work of the difficult and costly character of a ship-canal, a more attentive consideration of the superior advantages of the natural mouths, and of the fair probability of utilizing them, is needed."

This investigation is called for by your expressed desire "to have the views of the board of engineers on the question as to the expediency of improving the navigable waters of the Mississippi by the Fort Saint Philip Canal as an alternative to or a simultaneous measure, perhaps, with the improvement of the passes," and as I could not concur in the views of the majority of the board on these subjects, this separate exposition of my own is rendered necessary.

There are but two methods of improving the passes which call for notice:

1st. *Dredging*, in which may be included all the varieties of that process, such as "stirring up," "harrowing," &c.

2d. *Jettees* at one or more of the mouths by which to concentrate the current upon the bar and thereby cause its removal.

Of the first process only has any actual knowledge by experiment been attained, and some notice of the history of this experience will be in place.

Under the first appropriation for the improvement of the mouths of the Mississippi, in 1837, "*dredging*" with "buckets" was recommended by a board of engineers, and a powerful machine constructed and set to work. But its cost and the outlay upon the survey consumed the appropriation before the method had been tested; and no other appropriation was made till 1852. In that year an appropriation of $75,000 was made for opening "a ship-channel of sufficient capacity to accommodate the wants of commerce;" and it was further provided that the said money should be applied by "contract," and that the contract should be "limited to the amount appropriated."

In order to decide how to apply this appropriation under the stipulations of the law, the Secretary of War (Mr. Conrad) convened a mixed naval and engineer board, (its members were the late Commodore W. K. Latimer, U. S. N., the late Maj. W. H. Chase, United States Engineers, Maj. G. T. Beauregard, United States Engineers, and the undersigned,) and submitted to it certain queries. All these officers had served long on the Gulf coast, the three latter, as engineers, having had much experience with construction and engineering problems connected with the Lower Mississippi. Major Chase had, indeed, been one of the very first engineers to propose, in 1837, a ship-canal, and *the* first to define his views by a *project*, which has been noticed in my first report.

No other plan suggested itself to that board by which the $75,000 could be applied with some hope of obtaining any important result than that of "stirring up" the bottom; and upon their recommendation a contract was entered into with the Tow-boat Association, by which a channel through the bar at Southwest Pass 18 feet deep and 300 feet wide was to be made. The execution of this contract was the very first successful application of any artificial means to deepening the channels over the bars, and it *demonstrated* the efficiency of dredging by *that method*. Inasmuch, however, as the board could not foresee with certainty this success, they, in recommending another appropriation of $150,000, also recommended, *should in the mean time the dredging processes prove failures*, to apply it to the construction of jettees of the Southwest Pass, remarking that the "project of jettees is based upon

the simple fact that, by confining the waters which now escape uselessly in lateral directions to a narrow channel, the depth of this narrow channel must be increased—in other words, the existing bar must be cut away." As auxiliary to the jettee system, the board recommended the closing of certain minor outlets in order to increase the volume flowing through Pass à Loutre. The board concludes by saying that, should methods of operating upon the natural outlets—the mouths—"all fail," there is yet a plan to fall back upon, viz, A SHIP-CANAL. They express their conviction of its *practicability*, and recommend "that the engineer charged with these works should be directed to employ such time as he can spare to an investigation of the subject, having reference to the possibility of a future recurrence to this project."

No further appropriation was made till 1856, and as a consequence the 18-foot channel completed in 1853 was speedily filled. In the year mentioned an appropriation of $330,000 was made for the improvement of the passes. A board of engineers recommended that the proposals of the Tow-boat Association should be accepted for keeping open the Southwest Pass, by the already successfully tested method of stirring up the mud, and that a proposal of Messrs. Craig and Righter for keeping open Pass à Loutre by means of jettees, and closure of minor passes, be accepted.

By direction of the Secretary of War (Mr. Davis) their plans and proposals *for both* passes were accepted, and the contractors began at the Southwest Pass, by building on the east side a jettee about a mile long, *composed of a single row of pile planks*, strengthened *at intervals by piles*. Portions of this jettee were carried away by storms, and the contractors abandoned the plan, and were permitted to resort to the "stirring-up" method, by which they opened, in 1858, two channels 18 feet deep, which, as long as the process was continued, preserved this depth. (Physics and Hydraulics of the Mississippi, p. 455.)

Such, substantially, was the experience up to the interruption of all operations by the civil war.

In 1867 an appropriation of $75,000 was made, and a contract entered into, for "stirring up," which, however, was not executed.

The engineer in charge (the late Maj. M. D. McAlester) then designed a boat (the Essayons,) especially adapted to the stirring-up process, by agency of propeller-blades extending below the keel, and, with the balance of the appropriation just named and that of 1867, ($200,000,) the vessel was built, and the system, as improved by Major Howell, by the addition of the deflector, which more effectually directs the stirred-up material into the upper currents, has been since in operation, with eminent success.

"The results have been such" (in the language of Major Howell) "as to warrant yet more liberal action. With the success attending the work of dredging the bar at Southwest Pass during the past two years, the commerce seeking the port of New Orleans has grown rapidly.

"Lines of steamships before in the trade have built new vessels for it; other old lines have been attracted to it; new lines have their vessels in course of construction, and sailing-vessels in greater number than before have engaged in it, all taking fuller cargoes, making quicker trips, with greater profit to owners and reduced expense to shippers. The cotton trade of the upper cotton region, for a time partially diverted from this route, is returning, and a grain trade has been inaugurated which promises to attain large proportions.

"While the great benefit already derived from dredging is acknowl-

edged, there remains in the minds of commercial men doubt as to its continuance to meet the growing demand for deeper-draught vessels.

"There is yet more serious doubt regarding the continuance of suitable action on the part of Congress, in making appropriations seasonably and in amount to prevent interruption of the work. Distrust in the continued effectiveness of dredging can only be overcome by long-continued success, and simply retards commercial progress.

"Distrust of the continued good will of Congress is of more serious import. The work in progress is dependent for its continuance on an annual appropriation. It is of a character requiring continued work. Suspension for a few weeks or months will permit the natural agencies, always at work, to obliterate all evidences of previous improvement, and return the channels across the bar at the river outlets to their normal and obstructed condition.

"Such occurrence would be disastrous in the extreme. It would ruin the commerce now promising such good results, ruin the merchants now engaged in it, and destroy confidence in plans for its revival at any future time. Yet such occurrence is not improbable, as evidenced by the past record of the work.

"Legislative economy enters too largely into the spirit of American politics to permit of men engaged in legitimate business staking their wealth, when it will depend on the turn legislation may take. What is required to inspire confidence in the future of the commerce of the Mississippi River is a permanent outlet—not one of uncertain tenure. Dredging, from its dependence on legislation, does not offer such."

It is further stated by the engineer in charge, in an official letter to the president of the board, that, *provided* that enough money be furnished to keep the two dredge-boats now in service employed all the year round, except when under repair, and further *provided* the engineer have full control over the use of the channel, with authority to assess fines in cases where injury may result from ignorant or malicious handling of vessels in the channel, to be collected in the United States courts, THEN a channel may be made and maintained at one of the passes *with 20 feet depth at extreme low tide;* and the cost for the same would be $150,000 per annum for "running expenses," and a new dredge-boat, costing $250,000 every five years, or an average cost of $200,000 per annum. (See letter of Major Howell, appended.)

If these official expressions of the engineer in charge be not deemed strong enough, reference may be made to the following passages from his annual report of September 18, 1873:

> That natural causes effecting a blockade of the mouth of the Mississippi have been overcome by the system of dredging adopted, *so far as regards obtaining a 20-foot channel across the bar at the Southwest Pass,* is evidenced by my reports.
>
> Even the popular prejudice against dredging has been overcome, and the people of New Orleans, most interested to-day, acknowledge the good done.
>
> * * * * * *
>
> In consequence, with means at my command *abundantly able to overcome all natural obstacles to the formation and maintenance of a good channel at the mouth of the Mississippi River,* I have not been able to accomplish the latter, and this fact, with those who do not appreciate the other facts, discredits my work, the system of dredging, and my ability as an engineer, &c.

It has already been stated that the very first attempt at "stirring up the bottom" successfully created a channel on the southwest bar 300 feet wide and 18 feet deep, for the sum of $75,000. Subsequently, (1858,) Messrs. Craig & Righter having failed in their efforts at jettee construction, succeeded, by means of "stirring up the bottom with harrows and scrapers, dredging with buckets in some places," &c., in

making *two* channels 18 feet deep, *and as long as the process of stirring up the bottom was continued by them, the channels preserved the requisite depth.*" (Phys. and Hyds. of the Miss., p. 455.) Subsequently ~~(1839)~~ the Department took the work in hand, still using the plan of stirring up the bottom by "dragging harrows and scrapers" over it. "The plan proved to be successful, and a depth of 18 feet was maintained upon the bar for the period of one year, at a cost of $60,000."

Thus we see that the very earliest attempt, by improvised methods, at *scratching* the surface of the bar with harrows, &c., produced, for $75,000, an 18-foot channel; that the process was repeated in 1858 with the same success, and *two* 18-foot channels obtained; and finally, the thing was *again* done under the immediate direction of the Department, and for the small sum of $60,000 a depth of 18 feet was maintained for a period of one year.

In face of these *facts;* in face of the positive, formal, and official statement of the engineer in charge "that, *so far as regards obtaining a 20-foot channel,* the natural obstacles have been overcome," (reiterated under different forms,) and in face of the fact that since the proved success of stirring up by scraping with harrows, &c., *for* $60,000 *a year,* machinery expressly designed to this end has been invented and improved upon, under the eye of engineer officers, to be operated at an expense of *two hundred thousand dollars* per annum, the *majority** of the board advise *you that* "the results, so far, do not warrant the board at estimating a greater depth than 18 feet, at extreme low water, as capable of being maintained at the passes by means of the stirring-up "process," and, furthermore, that "this is inadequate to the requirements of the naval, military, and commercial services."

By reference to the best authority I have proved the adequacy of dredging operations on the bar by well-tested means; but I think there is yet room for improvement, and especially in diminishing cost. The utilization of the power of the current may perhaps be yet further effected,† while the attainment of 20 feet depth on the bar has by no means been established to be the maximum. As to *that* depth, however, we have the strongest assurances.

With 20 feet at extreme low tide, vessels drawing 22½‡ feet could, owing to the softness of the bar, frequent the port of New Orleans, and for mere commercial purposes probably 20 feet draught would be adequate. A draught of 23 feet will include 85 per cent. of the shipping of the world; and with a draught of but 18 feet vessels (steamers) can be built of 5,000 tons, carrying 70,000 bushels corn, or about 11,000 bales of cotton.§ It

* The engineer, Captain Howell, of course, could not concur in our opinion in so direct conflict with his official statements. In his paragraph of dissent he avows himself to be "the only engineer, so far as he knows," who believes his own assertion that the "natural obstacles to obtaining a 20-foot channel across the bar of the Southwest Pass *have been overcome,*" or who is so "sanguine" as to believe that with the two powerful and especially designed dredge-boats, and $150,000 per annum, he can accomplish more than *has been accomplished by others* without such machinery, and for $60,000. But he certainly *knew my opinion;* not a singular one, I imagine, or one for which it would be of importance to cite names.

† A simple design was made by one of the members of the board of 1852, (Major Beauregard,) and again brought to the attention of the general board. Its trial was urgently recommended by all the members of the first-named board, and by other competent judges.

‡Average high tide is about 1½ feet above "extreme" low tide. Vessels drawing a foot more than depth on bar *can* (though with some difficulty) pass. On the miter-sills of a lock a *clearance* of one foot is stated to me by one of our naval constructors to be necessary for vessels of heavy tonnage and large draught.

§ See prospectus of Atlantic, Great Western and Southern Steamship Company. The proposed vessels draw but 18 feet.

is clear then that, for commercial purposes, a depth of 20 feet on the bars of the passes will suffice to furnish a navigable outlet, and relieve the commerce of the valley from enhanced charges, arising from insufficient tonnage in the transports.

The engineer has, in language already quoted, very forcibly described the impetus given to commerce through the passes by the successful dredging operations of the last two or three years; but the benefit, he says, is qualified partly by the doubt whether the process will meet the "future demands for vessels of deeper draught," but still more by *doubt as to the uninterrupted annual appropriations by Congress;* and hence the *real* obstacle to that confidence which will justify business men in investing their money in lines of steamships of magnitudes such as will bring the cereals and cotton of the valley through this route, appears to be *uncertainty as to the annual appropriations by Congress.*

The remedy for this is clearly pointed out in the "Physics and Hydraulics of the Mississippi," in the very last paragraph of that work, (p. 456,) viz, "*that a permanent fund* be provided, untrammeled by restriction as to the mode of the expenditure, from which a sufficient sum annually can be relied upon for the continuous prosecution of the work," &c.

Congress has power, I presume, to provide such fund—or to make appropriations applicable for future years. But if absolute *freedom of use* be not claimed for the canal, if tolls enough merely for *maintenance* be imposed, then with equal propriety an amount no greater (for no greater is needed) may be raised from vessels passing the deepened bars.

An objection to a reliance upon the dredging process is urged that it could not be maintained during a period of war with a powerful maritime enemy. This objection implies a state of *continuous blockade* at the mouth of the river, and a protracted war. Protracted wars between powerful nations are no longer probable, they are ceasing to be *possible;* while the supposition of continuous blockade to one of our greatest seaports would be repelled, and indeed would be more destructive of the commercial use of the river mouths than the usual bar obstruction.

The objection is not therefore in the same category with the demand for the defense of the works of an artificial canal, and it is not an overruling one. Still an improvement of one or more of the natural mouths by which a sufficient depth should be afforded without the continuous use of machinery, and which would not be subject to the objection just cited, would be desirable.

In turning to the subject of jettees, I do not know how I can better define at the outset my position in relation to them than by quoting from the draught of a report which has been submitted to the board, and which has already passed through your hands:

> I can only reason on *probabilities* deduced from study of the river and the lights of experience; and so long as to establish the negative there has been, I need not say, no *trial* of the system, but not even a survey accompanied with a careful study and experiments, directed expressly to develop the cost and character of the work needed, I feel that I am justified in recommending it as *probably* furnishing the most speedy attainment of a deep-water channel, and one which will have some features of permanence.

In a passage already quoted from the report of the board of 1852, the *rationale* of the jettee system is explained. I further cite from the "Physics and Hydraulics of the Mississippi" the following:

> The development of the laws which govern the formation of the bars has removed all uncertainty as to the principles which should guide an attempt to deepen the channel over them. The erosive or excavating power of the current must be increased relatively to the depositing action. This may be done either by increasing the absolute velocity of the current over the bar or by artificially aiding its action. To the first class of works belong

jettees and the closure of lateral outlets; to the latter stirring up the bottom by suitable machinery, blasting, dragging the material seaward, and dredging by buckets. These plans are all correct in theory, and the selection from them should be governed by economical considerations.

Such is the theory, and no engineer has yet expressed a doubt as to the fact that concentration of the waters of one of the passes by jettees carried out to deep water, *would excavate the required deep channel.* The difficulty and the cost of construction, the alleged necessity of costly annual extension, furnish the arguments why this method should not be resorted to. While the general laws which govern the formation of bars at river mouths are universal, there are peculiarities in the formation due to the natural differences of character of the rivers and of the sea-shore where the mouth is situated. If the shore be itself sand or gravel, and not rock, a bar always forms whether the river brings down sediment or not. The latter material cannot, therefore, be regarded as in any sense the *cause* of the bar, though when it exists it is found to be the material of which the bar is composed. The most intractable bars are usually found to be of the former class; and yet, with few exceptions, every harbor on our northern lakes constituted by a river or creek mouth has been improved by the construction of parallel jettees. That those jettees need sometimes to be *prolonged* is no denial of their efficacy.

In the thirteenth volume of the professional papers of the Royal Engineers, four different instances of the application of jettees are described: Two, the Danube and the Oder, (the first a sediment, the second a non-sediment bearing river,) successfully; another, the Vistula, (sediment-bearing,) unsuccessfully; and the fourth, the Rhone, of which it is stated: "They cannot be said to have failed, (for they were never fairly tried,) though their failure *there* would constitute no argument against their employment elsewhere."

Concerning the Vistula it is stated, "*no more unfavorable circumstances for the opening of the river could be imagined*" than those that existed at the old mouth, where, for 150 years, jettees (*always used*, however) failed to produce an adequate permanent depth. In 1840 the river burst through a narrow tongue of land and formed a new mouth, five miles from the old one, to which "piers" (jettees) were *immediately applied*, by the effect of which, aided by dredging, a depth of 17 feet is obtained. Jettees were not, therefore, total failures, after all.

At the mouth of the Adour, below Bayonne, (not cited in the volume referred to,) piers were carried out one and a half miles long in nearly parallel lines and with a narrow channel. The bar here was "shingle," (*i. e.*, gravel or pebbles,) and the operation is described (Minutes Institution Civil Engineers, 1861–'62) as "a total failure."*

The conspicuous instance of the *success* of jettees is that of the Danube mouth. Here, as in the case of our own great river, a great sediment-bearing† river discharges into a (nearly) tideless sea:

The base of the triangle which constitutes the delta forms upon the general outline of the coasts of the Black Sea, a strongly-pronounced salient, which is connected with the primitive shore-line by curved contours. A complete analogy is thus found between the form of this delta and those of the other great rivers, the Nile, Ganges, and Mississippi. (*Annales des Ponts et Chassées, Nov.*, 1872.)

* Nevertheless the depth is said to have been increased; but inside, at a distance of half a mile from the original bar, an interior bar was formed," due probably to the sea-waves' action on the shingle.

† The ratio of solid to fluid in the Danube waters is by volume $\frac{1}{1272}$; nearly the same as for the Mississippi.

Nevertheless, compared with the Mississippi delta, there are very strongly-marked *differences:*

There were at the Danube delta two natural actions going on. Opposite to each of the mouths of the river there was an accumulation; between the mouths there was an erosion of the shore. If the river had not been there it was natural to suppose that the whole of the shore would have been eaten away uniformly; and therefore the amount of solid matter brought down by the river was not to be measured by the apparent width of the extension opposite to the mouths, but by the width of that extension added to the width of the recession in the parts between the mouths. This tendency to erosion from causes independent of the river was another circumstance conducive to success. (Minutes of Proceedings of Institution of Civil Engineers, vol. xxxvi, p. 231.)

And, again, the formation (at the Sulina mouth, at least) exhibits firmness and (sometimes) even hardness. The village of Sulina, at the very mouth, is, in part at least, of stone buildings, on the natural soil. The bar sometimes, and especially during times of floods of the upland rivers, (the *first* effect of high floods having been with the improved bar to deepen it, the *second* to reform it further out, and of harder materials,*) being incrusted with hard sand, which yields with difficulty to the ploughing action of a vessel's keel, and the lateral shoals on which the jettees were laid being sufficiently firm to support "rip-rap" construction without materially yielding.

Another point of *alleged* difference, very much insisted upon by many, is the *littoral current* off the Danube mouths. Colonel Stokes, R. E., (British commissioner,) states:

Its existence was ascertained before the works were carried out, the author having instituted a series of observations with floats to test the amount of the current, the result of which proved that there was a decided current across the mouth of the river, which extended as low as 4 feet below the surface in a depth of 10 feet. The depth on the bar at that time was 8 or 9 feet. It was also shown that during calms, northerly and northwesterly winds, there was a considerable littoral current from north to south, and during southerly and southwesterly winds, a surface-current from south to north: but it was so feeble as to indicate that the force of the wind had but just overcome that of the current from north to south. In strong westerly winds there was a counter-current setting in about 5 feet or 6 feet below the surface; but this was not observed during the northerly winds, which so generally prevailed at the mouth. The Kilia branch, fifteen miles north of the Sulina, discharged two-thirds of the water of the Danube into the Black Sea, the whole of which set past the mouth of the Sulina.

Seamen found a very constant current of from half knot to one knot per hour, setting from the north to the south along the coast of the Delta. Colonel Stokes therefore thought it established, that there was a littoral current generally from north to south across the Sulina mouth. (Minutes of Proceedings of Institution of Civil Engineers, vol. xxxvi, p. 247.)

To the undersigned Sir Charles Hartley stated that the current averaged about half mile, confirming also the fact of its occasional fluctuation.

Again it is to be observed that while each particular pass (and even each small "bayou") of the Mississippi delta thrusts out, in its own particular finger-like promontory, the Sulina mouth is not thus thrust out, but is on the general line of the shore.

The Danube divides at about fifty miles from the coast into the Kilia and Toulcha branches, of which the former conveys two-thirds (about) of the entire discharge. The latter and more southern branch again divides into the Saint George and Sulina arms; the latter running eastward nearly. The Saint George conveys nearly one-third, leaving to the Sulina but two twenty-seventhis. The mouth of the Kilia and St. George are about 40 miles separated, the Sulina mouth nearly midway between them, the trend of the coast-line being north and south. Finally it may be said, the discharges of the Saint George and the Southwest Pass of the Mississippi have the same ratios, one-third of the total discharge, and the Sulina the same ratio as the South Pass, (7½ to 8 per

* The usual depth was about 9 feet, varying, however, from 7¼ to 11¼ feet.

cent.) Hence, the total discharge of the Mississippi being more than three times that of the Danube, the Southwest Pass discharges three times as much as the Saint George, and the South Pass three times as much as the Sulina. The current velocities are, if anything, somewhat greater in the Danube than in the Mississippi, the inclination of surface in the Sulina 3 inches per mile during floods, and about 1 inch per mile at low water.

The sea-depths at three miles from land are 16 fathoms off the Saint George, and only 10 fathoms off the Kilia and Sulina.

On the other hand, at 1,000 feet outside the bar of the Southwest Pass, the Gulf is about 22 feet deep; at 4,700 feet, 100 feet deep; at 43,000 feet (8 miles) 300 feet deep; and eleven miles, 900 feet deep, 150 fathoms. (Physics and Hydraulics of the Mississippi, p. 444.)

The Kelia, *though the greater arm*, was deemed ineligible in consequence of its subdivision into numerous small delta arms of its own. *To the Saint George, possessing a good navigable channel with 16 feet* of water, (while that of the Sulina with but 13 feet was very bad,) was *given the preference.*

When the engineer presented his plans to the European commission it had *three other designs before it* "*from eminent technical authorities*, who had visited the ground:

In one respect alone all were agreed, and that was in recommending that whichever month were chosen, the system of improvement should be that of guiding the river-waters across the bar, by means of piers projected from the most advanced dry angles of the mouth; or, in other words, that of concentrating the strength of the river-current, on the bottom of the proposed improved seaward channel, by an artificial prolongation of the river-banks into deep water. (Minutes of Proceedings of Institution of Civil Engineers, vol. xxi, p. 284.)

The English, French, Prussian, and Sardinian governments then referred the whole subject to the decision of two military and two civil engineers. These gentlemen, in an elaborate report, unanimously condemned the jetty system, and "recommended the choice of the Saint George branch with a sea-entry and gates," (in other words, a "ship canal,") "independent of the mouth; a project diametrically opposed in principle to the system of improvement previously proposed by all the naval and engineering authorities, who had visited the several mouths of the Danube, and had studied their peculiarities on the spot." (*Ibid.*)

The final result of these complications and of the impatience of the merchants for some immediate relief was that the commission, under advice of its engineer, "resolved to improve the channel across the bar of the Sulina branch, by means of guiding piers of a temporary character, but carried out in the lines which the author had designed for permanent works."

It is not in place to go into particulars concerning the progress of a work protracted through many years through inadequacy of funds. The piers, as designed, were 5,850 and 4,310 feet long, starting at points on shore 2,500 feet apart, and converging to parallelism about 600 feet apart.

The results are thus stated by Sir Charles Hartley, (Minutes of proceedings of Institution of Civil Engineers, vol. xxxvi, pp. 208, 209:)

1. That when the European commission of the Danube began its labors, in 1856, the entrance to the Sulina branch was a wild, open sea-board stream, with wrecks, the hulls and masts of which, sticking out of the submerged sand banks, gave to mariners the only guide where the deepest channel was to be found.

2. That the depth of the channel varied from 7 feet to 11 feet and was rarely more than 9 feet.

3. That the site now occupied by wide quays, raised high above flood-level and more than two miles in length, was then entirely covered with water when the sea rose a few inches

above the ordinary level, and that, even in a perfect calm, the banks of the river near the mouth were only indicated by clusters of wretched hovels built on piles, and by narrow patches of sand skirted by tall weeds, the only vegetable product of the vast swamps beyond.

4. That in the summer of 1857, three months of constant dredging and raking on the bar produced no appreciable effect.

5. That on the completion of the provisional piers, in 1861, the depth on the bar increased to 17 feet, and Sulina, instead of being the worst harbor, at once took the highest rank among the best commercial harbors in the Black Sea.

Finally, by the prolongation of the south pier, the consolidation and rendering *permanent* the work, at an expense equal to the first cost of the temporary structure, and by other improvements, an effective depth of 20 feet was attained in 1872, and since maintained.*

So far from a rapid advance or protrusion of the bar having ensued, "the piers have hitherto had the effect of diminishing by more than one-half the old rate of the advance of the delta at the Sulina mouth as represented by the 24-foot line and 30-foot line of soundings; of encouraging the growth of the sand-banks directly under the shelter of the south pier; and of causing a rapid erosion of the sea-bottom northward of the north pier along its whole length, an action which has naturally extended itself to the line of shore, thus necessitating, as has already been observed, a prolongation of 694 feet from the shore-end of the pier. The causes of these phenomena may be briefly explained as follows: The slower advance of the delta, as limited by the tails of the 24-foot bank and of the 30-foot bank, is due to the circumstance that the great bulk of the silt-bearing waters of the river on issuing, as at present, at once into deep water beyond the pier-heads is, as a rule, carried far to the southeast by the littoral current, instead of flowing into the sea, as formerly, with a feeble and constantly decreasing current, by numerous shallow channels, which were always changing in direction and extent. * * * * The remarkable erosion to the north of the piers is probably chiefly due to the rebound of the sea against the north pier during heavy northerly and northeasterly gales."

Simultaneously with this it is observed "that opposite the Ochakoff mouth of the Kilia, the 6-foot line of soundings has advanced 6,000, and the 30-foot line 5,000 feet, since 1856, or at the rate of 333 feet per annum."

I have thus given, with the utmost detail that I could venture to use in such a report, the circumstances of the somewhat famous Sulina-Danube improvement, to show how and under what circumstances a river-arm, discharging only one-third of the water that is discharged by the South Pass of the Mississippi River, has been made to afford a good navigable entrance, with an "effective depth" of twenty feet, while the bar "advance" instead of being accelerated has been retarded. Those who examine the problem *without the light of these results*, would be slow to believe that the local circumstances were decidedly favorable; that they were *more* favorable than those offered by the Mississippi. The *hardness* of the shoals favors, indeed, construction, but indicates a more thorough sifting by the sea-waves of the sedimentary matter rolled along the bottom, while such a bar on a shallow coast directly exposed to storm-waves is usually an unpromising subject for improvement. The littoral current, at best feeble, scarcely, if at all, exceeds that which

* Since the prolongation of the south pier had prevented the formation of the bank between the two pierheads, there had been no symptoms of deterioration of the channel. * * * * Vessels had passed out during the spring of the current year drawing 20 feet 3 inches.—(Discussion of a paper by Sir Charles Hartley, May 13, 1873, Minutes of Proceedings Institution C. E., vol. xxxvi.)

is imputed ("Physics and Hydraulics of the Mississippi," p. 449) to the Gulf waters off the Mississippi bars.*

On the other hand the very rapid deepening of the Gulf immediately off the bars, and the favorable exposure of their external slopes to the action of the sea-waves and currents generated by easterly storm-winds, are circumstances decidedly favorable. Surely there is ground here, especially when we weigh the inestimable benefit of an open RIVER MOUTH, to pause at least long enough for a mature study and investigation, not merely on paper, but by surveys and measurement at the localities, to collect the special data which bear upon the application of the project to them, instead of by a hasty pre-judgment founded on inadequate knowledge deciding that there is *no* remedy to the evils *but* the gigantic and costly alternative of a ship-canal.

It is proper, however, to allude to the more prominent objections. One of them is based upon the following, from "Physics and Hydraulics of the Mississippi:"

*If the excavating power and depositing action of the Southwest Pass had been equal when the yearly advance of the bar was 700 feet instead of 338 feet, the least depth upon it would have been 21 feet. This increase of excavating power may be obtained by constructing two converging jettees, beginning where the depth of 22 feet is found, and extended to that depth outside the crest of the bar, which would give them a length of about 2.5 miles. * * The depth of 21 feet thus obtained must be maintained by the annual extension of the jettees 700 feet into the Gulf.*

This dictum is founded upon a theory of bar formation, which is doubtless true, and yet does not contain the whole truth; for were the Gulf waters fresh and of same specific gravity as those of the river, there would still be a bar; moreover, the stretching of any theory of so complicated phenomena to *numerical* results is generally putting upon it more than it will bear. Some confirmation may be attributed to the fact that Captain Howell's surveys show an advance of 500 feet to the southwest bar, while under the operations of his dredge-boats; dredging by this method, or its equivalent, has been in operation during a considerable fraction of the high-water periods since 1853, and it would be desirable to know whether a decided acceleration of advance has resulted; at any rate we need a wider induction than Captain Howell's survey yet furnishes. Without pausing on this point, or discussing the applicability of the theory to an equal deepening by jettees, I prefer to dismiss the southwest pass, as one to which an experimental application of jettees would be unadvisable. So I have always regarded it. To obtain 25 feet depth of water, it would not be wise to enter into contest with the forces of motion developed in the discharge of a stream larger than the whole Danube. The excessive *length* of pier-construction simply to reach the bar to be deepened, should be decisive as to the matter of selection.

The objection just treated, together with others arising from the peculiarities of Pass à Loutre, and the expense of construction, are dwelt upon at length in the report of the majority of this board. Simply to show that the cost need not, *à priori*, be set down as out of reasonable bounds, I selected the Pass à Loutre, and, in a preliminary draught of, a report made at New Orleans, sketched out an application of jettees. I stated that "from the point in the pass where the depth of 25 feet ceases to

* Vessels making for the Southwest Pass from the capes of Florida are, after east and southeast gales, carried to the westward of their reckoning. Hence, in part, the construction of a costly light-house on Timballier Island, sixty miles west of the Southwest Pass. Major Damrell, light-house engineer, confirms the existence of a western current off Mobile Bay entrance.

obtain to the outer crest of the bar is about two and a half miles. This has reference to the pass *below* the division of the north pass, not from any supposed lack of water, but because there was a shoal at the division; and, in short, to make a full estimate for what others might *allege* to be necessary, I commenced above the north pass, included the "stopping" of that pass, and made jettees four miles long instead of two and and a half. I placed my jettees in the natural banks or upon the shoals. The estimate of the majority is founded, apparently, upon taking a normal distance apart of 2,200 feet, preserving *perfect parallelism*, (by which the jettees are throughout their *entire length*, over four and a half miles, *laid in deep water*.) The closing of the north pass is pronounced not only a "necessary" but a "delicate" and withal costly operation, "which must be sought at whatever cost in order to meet the desired improvement."

The *exclusion* rather than the addition of this water would be desirable,* but as this is not the place for discussion of projects, I simply content myself with the bare statement, and remark further that even if the water-way is to be restricted to 2,200 feet for four and one-half miles, the selection of the best ground for the jettees at distances apart considerably greater than 2,200 feet is not debarred. Short auxiliary jettees of slight construction, perpendicular to the main ones, will contract the water-way. Such parallelism is not, however, suggested in the paragraph I have quoted from Physics and Hydraulics of the Mississippi, nor practiced at the Sulina.

For reasons above given the hypothetical application of the majority of the board is erroneous in principle and elaborately unfavorable. An average section (fascines and ballast) of 32 square yards (say 12 feet broad on top and 12 feet deep) is attributed the whole length of four and a half miles of each jettee, and on the bottom and slopes of this *total of nine miles* of "fascines and ballast" are laid an average of twenty tons of riprap per running yard, (increasing by 50 per cent. the average section just described,) a total of riprap (320,000 tons) more than one-third of that in the Delaware breakwater and ice-breaker. Two-thirds of the construction (admitting the lengths to be necessary) could be laid on the natural banks or on ground marked "bare at low water," and be little more than levees, and generally the location would not be exposed to the violent sea-action which requires the voluminous re-inforcement by riprap applied to sea-jettees of the character that seems to be adopted. (See Professional Papers, Corps of Engineers U. S. A., No. 22, pp. 60, 61.) The question submitted, however, is not so much "to recommend its trial" (of the jettee system) as to recommend its *consideration*, and that scrutiny and survey on which alone estimates can be based.

For the same reason, however, that I have from the outset regarded the Southwest Pass as ineligible, I would as a subject of initial operations dismiss from present consideration Pass à Loutre. In the discussion before the institution of civil engineers (Minutes 1861, 1862,) Sir Charles Hartley said "that he did not consider it an advantage to have a large body of water discharging at the entrance. *That was the only disadvantage of the St. George as compared with the Sulina.* The more the quantity of water the greater would be the amount of deposit;" and it is a conclusion of that engineer that "it is more advisable

*There is a very similar case presented at the St. George mouth of the Danube. The Kedrilles channel of the St. George branch, carrying two-thirds of the water, by a division very similar to that at Pass à Loutre, reaches its bar at a distance of two miles. In contemplating the improvement of this arm Sir Charles Hartley considered it would have been objectionable rather than desirable to close the other outlet.

to improve the mouth of a minor branch of a river rather than to grapple with the difficulties of a principal branch if that minor branch offer sufficient depth and width, or nearly so, for the navigation down to the point where its waters are discharged into the sea."

If this language had been used to describe the South pass of the Mississippi, it could scarcely have been more exactly fitted. As the shortest it is the pass of which the natural advance is least rapid; it is nearly straight. Its average depth from the head of the passes to the head of its offshoot, Grand Bayou, is by Talcott 27 feet, by the most recent Coast Survey chart 38 feet, thence to inner edge of bar 24½ feet by Talcott, and 29 feet by Coast Survey, (1867.) Its least width is more than 500 feet. We have here, then, a pass of which the *natural capacity* is almost precisely that which is needed, and of a magnitude amenable, with comparative ease, to works of improvement. Its channel can be easily improved and regulated, the bar at the head of the passes removed, minor outlets closed, and even (if desirable) more water be directed into it. From the bar the nearest unsubmerged shore is about two miles on the east side and one mile on the west, and these distances would lie generally in very shoal water. Hence for an experimental trial this pass should be selected.

The important fact that at the Sulina-Danube mouth the progress of bar advance has been retarded rather than accelerated,* that, in the opinion of the distinguished engineer who accomplished that work, such will *generally* be the effect of jettees (when the bar due to sediment of a muddy river is in question) should, I think, cause some hesitation in adopting a theoretical view of accelerated advance; especially as the theory leaves out of consideration the counteracting effects of currents and waves. But if reference is had to the theory, the case here offered is more analogous to that presented on page 445, Physics and Hydraulics of the Mississippi, in which the mouth is supposed removed to some point where the pass has its normal section and mean depth, and the Gulf to occupy its place, (*i. e.* that no bar has yet formed.) The carrying *forward* of the normal section and mean depth of a pass to the deep water of the Gulf has only this difference, that the process implies the erosion and deposit beyond of the material of the *existing* bar. In the hypothetical case the *formation* of the bar is admitted to require time.

I am not called upon to make a plan nor an estimate. If successful at all, (and I have endeavored to show that success is promised,) the cost will be a small fraction of that of the canal. On the other hand, the advantages of an open river mouth are inestimable. The needs of a navigation so great as that which now exists, and which in the future of the great Mississippi Valley must be fifty-fold increased, demand it.

It is said that "the time has come" when the needs of commerce demand the canal; but I answer that the *time will come* when there will be the same cry for a navigation unimpeded by locks—AN OPEN RIVER MOUTH—which we now hear for a canal. But in whatever aspect the question be regarded, the use of the river mouth for the next ten years is simply inevitable.

The conditions of the location and execution of a canal have received no adequate study. The plan, boldly and ably, yet so imperfectly, sketched out nearly forty years ago by one for seventeen years my commanding officer or professional associate, W. H. Chase, is yet, in its en-

*The permanent deepening on the bar which existed at this Danube mouth appears to be a well established fact. It is an experimental demonstration of the efficacy of longitudinal jettees for improving the bars at the sea mouths of rivers.—(Annales des Ponts et Chaussées, November, 1872.)

gineering features, the best plan extant; and the grave objections to *that* apply with even greater force to the present project, and demand new studies of location and an entire revision of plans of execution. It would be a rash confidence which would contemplate a realized "Fort Saint Philip Ship-Canal" earlier than A. D. 1884.

In the mean time shall the routes of commerce of the great West be yet more effectually than now diverted to the Atlantic ports; or shall the public confidence be directed to the *present* adequacy of the operations upon the bars; and shall the problem, which sooner or later *must come*, of an *open river mouth*, be solved?

Respectfully submitted.

J. G. BARNARD,
Chief of Engineers and Bvt. Maj. Gen., President of Board.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army,
Washington, D. C.

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ENGINEER OFFICE, UNITED STATES ARMY,
Newport, R. I., January 15, 1874.

GENERAL: As a member of the board of engineers considering the Fort Saint Philip canal project for connecting the deep waters of the Mississippi River and the Gulf of Mexico, directed by you to also consider the alternative proposition of making this connection by deepening the water over the bars in the natural outlets, I beg leave to say that on this last proposition I do not feel possessed of the data for a detailed report, nor do I see how this can be obtained but by costly experience. Any conclusions reached now must unavoidably rest upon what is, in a measure, assumed, and opposite conclusions will be reached by others using the same liberty.

My mind, however, is fixed upon the idea that the canal is the only project that will meet the commercial, naval, and military demands of the United States. Its feasibility has never been doubted by any one, and only on account of its cost have other methods been heretofore recommended. These other methods have always been regarded as experiments, and the reliance has been that, if they failed, the canal, as a final resort, was certain.

I believe the time has come when that which appears certain should be tried first.

The cost of the canal will not be great compared with the end to be gained; and there is no certainty that we will not have to come to it after great delay and expenditure upon other methods, none of which, when abandoned, will have aided in the least toward constructing the canal.

Very respectfully,

G. K. WARREN,
Maj. of Engineers, Bvt. Maj. Gen., United States Army.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army.